[illegible]

Plate 1.

James Hennell del. C. Rosenberg sc.

LONDON AND BIRMINGHAM RAILWAY.

London Entrance to the Primrose Hill Tunnel now in progress of erection

Designed by W. H. Budden. — Robert Stephenson Esq.re Engineer. Sept. 1837

Printed by Lad & Kinlaysde

PUBLIC WORKS

OF

GREAT BRITAIN

CONSISTING OF

Railways, Rails, Chairs, Blocks, Cuttings, Embankments, Tunnels, Oblique Arches, Viaducts, Bridges, Stations, Locomotive Engines &c

CAST IRON BRIDGES, IRON AND GAS WORKS,

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PLAN OF THE HARBOUR AND PORT OF LONDON,

AND OTHER IMPORTANT ENGINEERING WORKS WITH DESCRIPTIONS AND SPECIFICATIONS

The whole rendered of the utmost utility

TO THE

CIVIL ENGINEER,

TO THE NOBILITY AND GENTRY,

As Monuments of the useful Arts

IN THIS COUNTRY

and as Examples to the Foreign Engineer

LONDON & BIRMINGHAM RAILWAY STATION WATFORD

EDITED BY F. W. SIMMS, C.E.

153 PLATES

LONDON

JOHN WEALE

ARCHITECTURAL LIBRARY 59 HIGH HOLBORN

1838

TO

GEORGE RENNIE, ESQ., F.R.S.

&c. &c. &c.

THIS VOLUME,

ON THE

PUBLIC WORKS OF GREAT BRITAIN,

IS

DEDICATED WITH MUCH ESTEEM,

AND AS A GRATEFUL TESTIMONIAL OF A VALUABLE ASSISTANCE,

BY

HIS VERY HUMBLE SERVANT,

JOHN WEALE.

No. 59, HIGH HOLBORN,
January 20th, 1838.

PREFACE.

The great and important changes which this Country has experienced, and its proud elevation over its contemporaries in the scale of nations, may chiefly be attributed to the important character of its Public Works. These having been raised by the wealth of its inhabitants, called forth the powers and resources of the Country, enlarged both its Foreign Commerce and Internal Trade, and has converted the sterile plain into a highly cultivated, or populous manufacturing district, with everywhere the appearance of wealth and comfort. The unshrinking enterprise of the Nation has called, as it were, into existence these important and lasting monuments of its greatness.

The advantage to be derived by every student, in having a reference to the most approved works of his profession, to examine and acquaint himself with the principles of their construction, their various details, and the mode of execution, is too obvious to need more than a passing observation. Amongst the multifarious employments of the Civil Engineer, none have made larger calls in modern times upon his ingenuity than the construction of Railways, which, from their magnitude and novel character, may be considered as a newly-contrived means of internal communication. The formation of such works require constructions of various kinds and degrees of magnitude, and many that have been executed have presented some new features in Engineering. To bring, therefore, before the attention of the student and practitioner generally, some of the best examples of works of this kind, in combination with examples of such other character of works as fall within the province of Civil Engineering, cannot fail of being useful to the practitioner for reference, and to the student, by maturing his judgment. It is the professed object of the present Volume to supply, in part, this important desideratum; and, should it ultimately be found to answer this end, it is proposed by the Proprietor to renew the subject from time to time, by publishing the details and particulars of the most important works of which this country may be so justly proud.

The following work originated in the purchase of the Plates and Copyright of Strickland's 'Reports on Canals, Railways, Roads, and other Subjects, made to the

Pennsylvania Society for the Promotion of Internal Improvement,' the proposed re-publication of which, after having had an extensive sale, both in this country and America, suggested the utility of extending its sphere of usefulness by making it the nucleus about which to collect the most important works of the kind treated of by Strickland, and thus form a volume which, for the importance and accuracy of its contents, would be of real utility. In carrying this plan into execution, a careful revision of the original work was gone into, as far as we were able to obtain the necessary information; very little of the original matter has been retained, and such plates as were found to be incorrect representations of their subjects were cancelled, and correct ones substituted—as, for instance, the Thames and Medway Canal and Tunnel, and the Harecastle Tunnel; for the correct Drawings and particulars of the former, we are indebted to William Tierney Clark, Esq., the Engineer, who designed and executed the Tunnel; and for the latter, to Mr. James Potter, who furnished us with the original working Drawings, from which he constructed that Tunnel, under the superintendence of the late Thomas Telford, Esq. The new matter has been for the most part communicated by the eminent Engineers who designed the various works described, and may therefore be relied upon for its accuracy; and throughout the preparation of the whole work, the utmost vigilance has been used to prevent the admission of error, which it is hoped (although in a work of this magnitude scarcely to be expected) will nowhere be found, either in the letter-press or the illustrations.

In conclusion, we have to acknowledge the kindness of those numerous professional Gentlemen, who have both given their valuable time and information to assist in making the work complete and correct.

F. W. SIMMS.

Greenwich,
January 20th, 1838.

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ENTRANCE TO THE STATION AT THE LONDON TERMINUS.

LONDON AND BIRMINGHAM RAILWAY.

AN Act of Parliament for carrying this important national work into execution, entitled "An Act for making a Railway from London to Birmingham," was passed on the 6th of May, 1833. By this Act the Company were empowered to raise "any sum of money for making and maintaining the said Railway and other Works by this Act authorized, not exceeding in the whole the sum of two millions five hundred thousand pounds, the whole to be divided into twenty-five thousand Shares of one hundred pounds each; and in case the money so authorized to be raised by subscription be found insufficient for the purposes of the Act, the Company to have power to borrow any further or additional sum, not exceeding in the whole eight hundred and thirty-five thousand pounds, on the credit of the said undertaking." A second Act was obtained on the 3rd of July, 1835, entitled "An Act to enable the London and Birmingham Railway Company to extend and alter the line of such Railway, and for other purposes relating thereto." By this Act the Company were empowered to extend the Railway from the first proposed Terminus near the Hampstead Road, in the parish of St. Pancras, to Euston Grove, on the north side of Drummond Street, near Euston Square, in the same parish; and also to vary the position of the line in the parishes of Stowe, Weeden, Dodford, Brockhall, Norton, Whilton, and Long Buckby; also, to divert the course of the rivers Ouse and Avon, at such places where they are crossed by the Railway, &c. &c. By this second Act the Company also obtained power to borrow the sum of one million pounds instead of the eight hundred and thirty-five thousand pounds named in the former Act. A third Act of Parliament was obtained by the Company on the 30th of June, 1837, entitled "An Act to amend the Acts relating to the London and Birmingham Railway." By this Act the power was obtained to raise by bonds, under the common seal of the Company, the further sum of one million pounds.

This magnificent undertaking was designed by Robert Stephenson, Esq., and under his direction the work has made great advances towards completion, which when accomplished, will form, in connexion with the Grand Junction Railway, already completed, a great artery of communication from London through the Kingdom, in a north-westerly direction, producing an interchange of those social, moral, and commercial benefits, which invariably improve the physical and political condition of kingdoms.

The most important works upon this line are represented in the plates accompanying these pages; they being copies of the Contract Drawings, and accompanied by the Specifications from which they were executed, will furnish the practical engineer with every necessary particular concerning their details. Commencing with the station at the London Terminus, near Euston Square, we shall give the works in the order in which they succeed each other on the line. The engraving at the head of this article represents the magnificent entrance to the station at Euston Grove, designed by Philip Hardwick, Esq., and now rapidly advancing towards completion.

EUSTON AND CAMDEN STATIONS.

LONDON TERMINUS.

In all great travelling establishments the utmost perfection in the multifarious arrangements becomes essential to prevent confusion, and to facilitate business. If order and precision had been found necessary in the smaller establishments to which we have hitherto been accustomed, how much more essential must it be to facilitate the traffic of so immense a concern as that of the London and Birmingham Railway, where, comparatively, such numbers of persons are going and returning at each departure and arrival of the trains, and where, without a most perfect system of management throughout its numerous details, business would be retarded, the passengers' goods mislaid or lost, and inextricable confusion would result. The fact, however, is far otherwise; the whole business is conducted with a precision resembling the movements of our most admirable machinery; the arrangements of the offices of the depot or passenger station are well contrived, and upon a most magnificent scale. Plate IV. contains a ground-plan of the London Station of this Railway, at Euston Square; the grand entrance, as before observed, is now (October, 1837) in the course of erection; the principal or public carriage entrance leads to an area enclosed by a wall marked A A A, &c., thus separated from the various lines of Railway, it must greatly tend to prevent confusion. Beneath the colonnade are doors leading through the various offices to the departure stage, which is an admirably paved platform, from which the passengers pass into the various carriages; the arrows point the direction in which the departing and returning trains move. On the opposite side of the station an arrival stage or platform is erected, similar to the one above named, and thus, by separating the arrivals and departures, another source of confusion is avoided.

The locomotive engines do not come to the station at Euston Square, but stop at that near the Hampstead Road, immediately on the north side of the Regent's Canal, nearly one mile distant. An inclined plane, having variable rates of inclination,* commences at Wriothesley Street Bridge, and terminates at the Regent's Canal; in returning, the trains pass down this inclination by the action of gravity,

* INCLINATION OF EXTENSION.

Chains.		
13½	Level	Hampstead Road.
16½	Rise 1 in 66	Hampstead Road to Crescent Place.
17	Rise 1 in 110	Crescent Place to Park Street.
9	Rise 1 in 132	Park Street Bridge.
16	Rise 1 in 75	Park Street to Regent's Canal.

and their ascent on departure is effected by attaching them to an endless rope, which passes round a sheave sunk below the level of the ground near Wriothesley Street Bridge, and passes over a vertical sheave (Plate V.) at the other extremity of the inclined plane, on the north side of the iron bridge over the Canal; this sheave is also beneath the surface of the Railway; the rope then passes round a horizontal sheave (called in the plan a tightening sheave) to another vertical one, or previously round a smaller intermediate vertical sheave when a greater degree of friction is required; this brings the rope again above the surface, and in the direction of the first sheave at Wriothesley Street Bridge, thus constituting an endless rope. In order to give motion to the rope, two marine steam-engines, of sixty horse power each, are applied to turn the largest vertical sheaves on each line of Railway; for it may be observed from the plan that two double lines of Railway connect the Euston and Camden or Hampstead Road stations. In order to keep the endless rope always in a proper state of tension, there is an admirable contrivance which acts, in this case, as a spring; thus, the horizontal or tightening sheave (Plate V.) is fixed on a stage which is moveable, on a pair of rails (or railway) in the direction of the rope; from this stage a rope or chain passes over a roller into a well a little distance in its rear, and there suspends a counterbalancing weight; this weight is sufficient to draw the tightening sheave with considerable force towards the well, and thus keeps the rope in the requisite degree of tension, however the weights of the different attached trains may vary. The whole of these extensive works, of which the plan is represented at Plate V., are beneath the surface of the Railway, or underground, and therefore are invisible from above, with the exception of the two admirably proportioned chimneys which rise from the surface of the ground on each side of the Railway to a towering height, and which have so imposing an effect. They are represented in perspective in Plate III., as seen from the south or London side of the iron bridge which crosses the Regent's Canal; the details of their construction in plan, elevation, and section, are also given in Plate V., accurately reduced from the original working Drawings.

The Euston Square station is that intended for passengers, and the Camden station for heavy goods and merchandise, for which it is particularly adapted, being at the side of the Regent's Canal, by which means a water communication may be obtained for the merchandise and produce of the manufacturers of the midland counties, with the shipping in the Port of London, and hence with the whole world.

The Roof of the Passengers' Arrival and Departure Shed, at Euston Grove, has a very light and elegant appearance; it is constructed principally of wrought-iron, the bressumers, columns, and gutters only being of cast-iron. The entire width is eighty feet, formed in two spans of forty feet each, a row of iron columns and bressumers supporting the rafters in the centre and outside, as shown by the engraving, and on the opposite side by iron corbels built in the wall, and further secured thereto by strong bolts and nuts; the rafters are six feet eight inches apart, and are of wrought-iron, in form of the letter **T**; the slate battons, as they may be called, are of angle iron, firmly rivetted to the back of the rafters at such a distance as the slates require, and to which they are secured by strips of copper. The roof is firmly tied from side to side by a tension rod of one inch and a quarter diameter, to each pair of rafters, and is further supported and braced by strutts of **T** iron and suspension rods, with nuts and screws to adjust their length, as shown in engraving. The entire length of the roof is two hundred feet; the gutters are cast in lengths of ten feet each, joined together by flanges and bolts, and so fixed as to form an incline towards each column, which being cast hollow and having a pipe connected with a drain, they form a convenient and easy conveyance for rain from the roof. (Plate VII.)

The Roof of the Locomotive Engine House, at Camden Town, is of very similar construction to the one above described; the rafters are of **T** iron, and the slates are supported by angle iron rivetted to the rafters. There are cast-iron chairs secured down to a stone coping on the walls, and from which the rafters spring; each pair of rafters is tied by means of a tension rod, and otherwise supported and braced by strutts of **T** iron, and suspension rods of round iron, which make the whole very firm, and gives it a light and pleasing appearance.

Both these Roofs were manufactured and erected by Messrs. Cubitt, of Grays Inn Road, under the direction of C. Fox, Esq., now Resident Engineer to the Company.

LONDON AND BIRMINGHAM RAILWAY EXTENSION

CONTRACT.

SPECIFICATION of the several Works to be performed in making and completing a part of the said Railway, commencing at a point marked A (on the plan), in a line with the faces of the houses on the north side of a street called Drummond Street, in the parish of Saint Pancras, in the county of Middlesex, and terminating at a point marked C, about ten yards northward of the towing-path of the Regent's Canal, in the same parish.

EXTENT OF CONTRACT.

This Contract includes the formation and completion of so much of the Railway as shall be included between a point marked B, at the termination of the intended depot, and about 275 yards from the hereinbefore-named point marked A, to the hereinbefore-mentioned point marked C, being a distance of about seventy-four statute chains.

It comprehends the following works, viz:—

The making and erecting of the hoard, or temporary fence herein specified, to be erected before the commencement of any of the other works.

The formation of the whole of the excavation, embankments, and spoil banks, represented upon the plan.

The erection, backing, and completing of the several retaining walls, shown in the Drawings, together with that part of the parapet walls of the embankment, and the piers and arches which support them, and the pillars and iron palisading on the top of all these walls.

The erection of the following bridges, viz:—

The bridge under the intended street to be called Wriothesley Street.

Ditto 1 and Ditto 2, on the Duke of Bedford's estate.

The bridge or covered way under the Hampstead Road.

The bridge under Stanhope Place—Plate VIII.

The bridge under Crescent Place

The bridge or covered way under Park Street—Plate VIII.

The bridge over the Regent's Canal—Plate IX.

The formation of, and completing the several approaches to, and roads over each of the foregoing bridges, and the paving and flagging the road and footway, in such case or cases as are shown in the Drawings.

The paving and railing of the areas, flagging the footways, paving the carriage-way, and erecting dwarf walls and palisades for Wriothesley Street, as shown in the Drawing.

The restoring the surface of the carriage-way and foot-path of Granby Street to its present condition, including the finding and fixing of the iron railing, erection of walls, and all other work necessary thereto, and specified in the Drawing.

The diversion of such roads as are shown in Drawing, No. 2, together with the metalling and completing the roads over the Hampstead Road bridge and Park Street bridge, together with the intended new road extending from Park Street, through the Oval, to the Regent's Canal.

The formation of drains in the excavations and embankments, together with those in such other places as may be specified in the Contract Drawings.

The laying, and ballasting, and draining of a quadruple line of permanent way.

The providing of all timber, lime, bricks, stone, iron, concrete, and other materials, for the furtherance and completion of the works.

The doing of all other works mentioned or described in the accompanying Specification and Drawings.

Also the execution of the following

EXTRA WORKS.

A wall on the north side of the Regent's Canal of a similar nature to that in the embankment between Park Street and the Canal bridge.

CULVERTS.

Including excavating the foundations, backing and completing the same, of the several internal bores or diameters shown on the Drawing, to be executed at the places where they may be required.

The wing walls to the north abutment of the Canal bridge.

The preceding enumerated Works, whether comprehended in the Contract or extras, and the mode of execution, are described in the Specification of each particular work, and their forms and dimensions are represented in the accompanying Drawings, which are referred to in this Specification; but should any discrepancies exist between the Drawings and Specification, or any ambiguity in them, the same are to be referred to the Engineer, whose decision shall be conclusive. Also, anything contained either in the Drawings or Specification shall be equally binding upon the Contractor, as if it were contained in both.

The written dimensions upon the Drawings are to be taken in all cases in preference to the scale attached.

FENCING.

Immediately on obtaining possession of any part of the ground, and before the commencement of any work thereon, the Contractor shall effectually surround and enclose the same with a hoard or close paling, six feet six inches in height; the situation of the hoard is shown on the plan by a black-dotted line.

The hoard is to consist of uprights six inches by four inches scantling, morticed to receive their horizontal rails of the shape shown upon the Drawing, of a scantling not less than three inches by two inches, to which boards shall be nailed with good tenpenny nails, as shown in the Drawings, so as effectually to prevent any one from looking through at the works. The tenons must be fixed into the mortices by wooden pegs. Should the hoards decay or become damaged during the time that the ground

enclosed by them remains in the possession of the Contractor, he shall replace it, or any part of it so damaged, with work equal to the first erection, to the satisfaction of the Engineer.

All drains, or alterations in, or deviations from existing drains and water-courses, which may be necessary for the exclusion of water from the excavations, for the prevention of damage to the adjoining property, or for any other purpose whatever, during the progress of the works, shall be made by the Contractor at his own expense.

EXCAVATIONS AND EMBANKMENTS.

The part coloured red on the plan, shows the direction of the Railway and the area of land which will be purchased by the Company.

The part coloured yellow, will be rented by the Railway Company, and the Contractor will have liberty to enter thereon and erect any temporary houses, offices, &c., necessary during the progress of the works, or any machinery for excavating and embanking, which shall not be specially prohibited by Act of Parliament for making the extension of the Railway.

The embankments are coloured green, and the excavations red, upon the section.

EXCAVATIONS.

The red line upon the section describes the tops of the embankments and bottoms of the excavations, previous to the laying and ballasting the permanent way.

The black undulating line, describes the present natural surface of the ground along the centre line of the Railway, and shows the heights of the embankments, and depths of the excavations, from which data their contents have been calculated, upon the supposition that the area of any cross section in side long ground, does not differ from the area of a similar section in level ground.

Plans and sections of an excavation, embankment, and spoil bank, are shown in the Drawings.

The excavations are shown in the drawings, and includes the excavating necessary for the retaining walls and their foundations.

The excavations shall be carried on in such lengths as the Engineer shall direct, and their sides and faces must be supported by such timber or other mode as shall be to his satisfaction, at the expense of the Contractor, during their progress, and until the completion of the retaining walls.

The face of the excavation shall in no case be carried on more than forty feet in advance of the completed retaining wall, without the written permission of the Engineer.

Whenever or wherever springs, streams, or soaks of water, may appear and issue from the face or the sides of the excavations, or any other portion of the work, the Contractor shall, at his own expense, take all such precautionary measures of draining, damming, stopping, lading or pumping such water, or otherwise getting rid of it, as the Engineer shall direct, in order to prevent any injurious effect either during the progress or after the completion of the work.

EMBANKMENTS.

The embankments are to be made of such height, and at such slopes, as are shown in the section, and the drainings and slopes must be carefully trimmed to the proper inclination as the work proceeds.

Each embankment must be carried forward uniformly, as nearly at the finished height and width as

the allowance for shrinking will admit of, and this allowance shall not exceed or fall short of the quantity deemed requisite by the Engineer.

In all cases this must be carefully and strictly attended to, in order to avoid the necessity of making any subsequent additions either to the heights or widths of the embankments, to bring them to their proper level and dimensions.

As the embankments advance and become consolidated, their sides shall be carefully trimmed into planes or faces, having the proper slopes specified on the section, and the faces of the slopes are then to be neatly covered with soil, not less than one foot in thickness, to be taken from the surface of the ground belonging to the Company.

The Contractor will also be required to cover with soil, of not less than two feet in thickness, the whole (excepting the slopes and roadway) of the embankment or spoil-bank, which is intended to form a crescent garden on the estate of His Grace the Duke of Bedford. The Contrator may obtain the soil for this purpose from the surface of any adjoining excavation.

In the formation of the excavations and embankments, the Contractor must provide, at his own expense, all the rails, chairs, keys, spikes and sleepers, as well as all the waggons, barrows, planks, and all other machinery, implements, and materials, together with all labour that may be necessary for executing his contract.

The Contractor will be required to do all that may be directed by the Commissioners of the Metropolis Roads, in the way of watching and lighting, and other precautionary measures, during the progress of constructing the tunnels under the Hampstead Road and Park Street, for the public safety, convenience, and rotection of the Metropolis Roads.

GENERAL STIPULATIONS,

Which are to apply to the whole of the Bridges, Walls, Culverts, and other Works, except where specially directed otherwise.

BRICKWORK.

All the bricks made use of shall be sound, well-shapen, and thoroughly burnt. Malm-bricks must be used in the face of the works, and the bricks used in the face of each bridge wall, or other separate portion of the work, must as nearly as possible resemble each other in size, form, and colour. No bats may be used on the work, excepting where required for breaking bond, or in such cases as the Acting Engineer may direct. And no joint of mortar shall exceed a quarter of an inch in thickness.

No difference of workmanship will be allowed between inside and outside work, and the whole of the joints must be flushed up solid with mortar or cement where required, or occasionally grouted, as the Engineer may from time to time direct. The outside joints must be neatly drawn and pointed, except in certain cases to be shown on the Drawings, where they must be neatly tucked. Very great attention must be paid to the flushing of the joints. The bond will be Flemish or otherwise, as the Engineer may direct.

MORTAR.

The mortar shall consist of the best burnt Dorking or other lime, equally good and approved, and clean sharp river sand, mixed in proportion of three measures of sand to one of lime: they must be mixed in a dry state, and well tempered by being passed through a pug-mill with a proper quantity of water.

ROMAN CEMENT.

The Roman cement shall be of the best quality, and shall be mixed with an equal quantity of clean river sand.

No cement shall be used which has set, or become hard.

IRONWORK IN GENERAL.

The whole of the cast-iron, except that otherwise specified, shall be of good grey iron of No. 1 pig; no open sand castings will be allowed. All the wrought-iron is to be of the best merchants' test, as the Company's Engineer may direct; provided that such tests do not exceed a strain of eight tons per inch, sectional area, of wrought-iron, and five tons per inch, sectional area, in cast-iron. Great care must be taken that all the castings be perfectly clean, smooth, and even, free from air holes, and all other defects, and entirely corresponding to the Drawings furnished by the Company's Engineer. In the skew girders the proper wind must be strictly preserved.

TIMBER.

All timber employed either temporary or permanently in any part of the works, shall be approved by the Engineer.

CONCRETE.

The concrete shall consist of good coarse gravel mixed with unslaked lime, in proportion of five measures of gravel to one of lime, and beat up with a proper quantity of water. It shall not be mixed up until wanted for use.

ARCHES.

Brick arches shall be built in concentric half-brick rings, or in such other manner as the Engineer shall direct, and counterforts, abutments, and spandrills, shall be so worked and bonded into the arch, as he shall direct. When the arches are askew, the bricks must be laid in proper spiral lines.

BACKING.

The backing will consist of brickwork laid in mortar, as hereinbefore described under the head of Brickwork.

WINGS AND SPANDRELLS.

The wing walls shall be of the description of brickwork before specified; they will be built as shown upon the Drawings. The spandrells will be of precisely the same description as the wings: the bricks must be cut so as to make them fit the arch.

FILLING IN OVER ARCHES.

The space between the wing walls, arch, and backing, of the bridges shall be filled in with hard dry materials, excepting such parts as is shown upon the Drawings to be occupied by concrete. The materials for filling shall be good gravel, or such other material as the Engineer shall approve, and shall be well punned, rammed, and beaten down. In case the Engineer shall permit clay to be used, it shall be firmly punned down, in layers of not more than nine inches thick, until within eighteen inches of the level of the surface of the roadway, and in either case, the Contractor shall then fill in that depth, with gravel or broken granite, as directed under metalling of roads hereinafter described.

STONE IMPOSTS.

Where stone imposts or springing courses are used, the stones shall always be equal to the full thickness of the arch; and no stone shall be less than two feet six inches long, and when required they shall be dowelled together.

In case of skew arches, the skew backs must be worked so as to suit the oblique direction of the springing of the courses, and in every case the stones shall be fair tooled all over, excepting at the back, which may be left rough.

STRING COURSES.

These must be of the form and dimensions shown upon the Drawings. No stone must be less than three feet in length, and the whole to be throated underneath.

All the surfaces, excepting the back, shall be fair tooled, except were otherwise shown.

COPING.

To be set of the form and dimensions shown upon the Drawings. No stone shall be less than three feet in length, and each stone must be dowelled and leaded to the adjoining one. The caps for the pillars must each consist of one stone.

The coping shall be fair tooled all over, and a throating of half an inch wide cut on its underside.

STONE.

All the stone used throughout this Contract shall be Yorkshire, Bramley Fall, or stone fully equal to it in quality, and approved by the Engineer.

The string course, parapet walls, and coping, shall not be put on until after the centres are struck, which shall not be done without the permission of the Engineer.

EXCAVATING FOUNDATIONS, PROVIDING FOR CENTERING, &c.

The Contractor is to excavate for the foundations of all bridges, culverts, and other works to keep out the water; place dams, and provide all centering, planks, and tools of every description necessary for the perfect execution of his work, at his own expense, and to be included in the amount of his Tender.—And in case of the foundations of any of the works requiring, in the opinion of the Engineer to be carried lower than is shown upon the Drawings, the Contractor is to make such extra excavations, and to do all extra pumping or other contingent works incident thereto, at his own expense.

In case the Engineer should see fit to cause the foundations of any part of the works to be piled, the Contractor shall provide, drive, and fix, all such piles, waling, and other timbering, but will be allowed for the same as an extra work.

RETAINING WALLS IN GENERAL.

The various retaining walls are respectively shown on Drawings, Nos. 3, 5, 11, 14, and 18, where their several lengths, heights, inclinations, and curvatures (where such occur) are shown. The first of these walls is that which divides Wriothesley Street from the intended depot, and is represented on Drawing, No. 3. The next walls extend from Wriothesley Street bridge to the Hampstead Road bridge (vide Drawing, No. 5). From this last-mentioned bridge the walls extend to Crescent Place

bridge (vide Drawing, No. 11); from Crescent Place bridge they continue to the bridge under Park Street, as shown on Drawing, No. 14; from Park Street bridge to the Regent's Canal, they are represented on Drawing, No. 18.

RETAINING WALLS.

Sections and elevations of retaining walls are shown on the various Drawings.

The faces of these walls will be a curved batter, the radius of this batter will be fifty feet, giving an average batter of two and a half inches per foot on twenty feet in every case, excepting in the walls from Crescent Place to Park Street, which have a radius of sixty-one feet eight inches, being an average batter of two inches per foot on twenty feet.

The whole of the brickwork of the walls will be laid in courses, radiating from the supposed centre of the curve of the batter. The walls will increase in thickness the nearer they are to the foundations by half brick off-sets, and the footings will consist of steppings of two courses of brick, projecting one quarter of a brick.

One foot thickness of concrete will be placed under the footings of the walls; it will project six inches from the footings in front, and be flush with the neat work behind.

The space at the back of the walls shall be well punned in with clay. The faces of the walls will be broken at intervals of sixteen feet, or thereabouts (as near thereto as consistent with dividing a given length of wall into an equal number of parts), by pilasters four feet four inches wide, projecting one half brick, built and bonded with the rest of the wall.

Counterforts will be built at the back of the wall equidistant between the pilasters, and bonded into the wall. A stone plinth six inches thick must be built in, at the required height, and the wall above it will recede one quarter brick from the face of the plinth.

In excavating for, and erecting the walls, the Contractor will be required to provide and erect, at his own expense, all such centering, leading frames, plumb rules, and other implements and materials as the Engineer may deem requisite for the expedition or soundness of the works; and also all such other iron work, timbering, bars, sills, and pollings as the Engineer shall think necessary for protecting the face or sides of the excavation, or any other part of the work.

As soon after the erection of the walls as the Engineer shall permit or require, the Contractor shall proceed to cope them with stone. The coping shall then be surmounted with pillars, four feet high and four feet wide, capped with a weathered stone cap nine inches thick, placed one over each of the pilasters of the wall.

The palisades must then be fixed between the pillars, and holes cut in the stone for their fastenings.

At the termination of the excavation beyond Park Street, shown on Drawing, No. 18, the walls change their construction and become parapets, supported on arches, the piers of which descend through the embankments, and have foundations excavated in the natural ground. These piers and arches will be erected before the formation of the embankment. These walls will be coped, and palisades and pillars fixed thereon, in the same manner as the retaining walls.

PALISADING.

The palisading for the retaining walls is shown in Drawing, No. 23. It is all of the same pattern, and will consist of a wrought-iron hand-rail, rivetted in lengths of cast-iron open work. The hand-rail will be in lengths of sixteen feet six inches long, or more if required. The castings will be about three

feet six inches long, and about four feet high; they will have solid projecting feet, which must be let into the stone and run in with lead. The whole must be constructed and fixed in a proper and workmanlike manner. The hand-rail shall be of the best merchants' iron, and the castings of No. 2 pig.

WRIOTHESLEY STREET BRIDGE.

This bridge is to be built on a part of the Railway marked on the Plan Drawing, No. 2, where the balance line will be about a foot excavation. It will cross the Railway at an angle of seventy-six degrees, and will consist of iron-work, stone, and brickwork.

The foundations will be of concrete, one foot in thickness, as shown on the Drawings, and hereinafter described under the Specification for Stanhope Place bridge. The pier and abutments will be constructed in the same manner as those for the bridge under the Hampstead Road, hereinafter described. The girders will be cast askew, and the cross arches built in the same manner as those in the bridge under Park Street, hereinafter described. The coping, parapet, string course, and dentels, will be stone. The bridge is represented, and its details given, on the Drawing, to which the Contractor is referred.

For particulars of materials and workmanship, see General Directions hereinbefore given. The granite paving, for a moiety of the road to and over this bridge, must be provided and laid by the Contractor, according to the Drawing. No stone must be less than twelve inches by six inches, by eight inches, good sound granite. The flagging must be the best Yorkshire, and the fixing of the whole, and otherwise completing the street, must be duly attended to.

BRIDGE No. 1.—ON THE DUKE OF BEDFORD'S ESTATE.

This bridge will be built at a part of the Railway marked on the Plan Drawing, No. 2, where the excavation is about nine feet deep; it is askew, crossing the Railway at an angle of seventy-six degrees. The faces will be stone; the soffit of the arches will be laid in spiral lines, as hereinbefore described in the General Stipulations. The pier and abutments will resemble those hereinafter described for the bridge under the Hamsptead Road. In other respects this bridge resembles that under Stanhope Place hereinafter described. For particulars of materials, see General Directions hereinbefore given.

BRIDGE No. 2.—ON THE DUKE OF BEDFORD'S ESTATE.

This bridge will be built at a part of the Railway marked on the plan Drawing, No. 2, where the Railway is in about thirteen feet excavation. It is five feet wider than the last-mentioned bridge between the parapets, but in other respects exactly resembles it. The Contrator is referred to Drawing, No. 7, and to the hereinbefore-contained specification for bridge No. 1, on the Duke of Bedford's estate.

BRIDGE OR COVERED WAY UNDER THE HAMPSTEAD ROAD.

This bridge crosses the Railway at a part marked upon the Plan Drawing, No. 2, where it is in about twenty feet excavation. Its total length is 339 feet. It will be built on an inclination of one in sixty-six, and will consist of iron-work, stone, and brickwork. The foundations will be of concrete, as hereinbefore specified in the other bridges. The face of the piers and abutments, the imposts, plinth of the parapet, and pillars of the same, are to be stone, as also the facing of the plinth of the pillars on the pier. The pier will consist of a series of pillars with inverts sprung between them, and the impost stone laying on the top from pillar to pillar, above the opening. Each of these stones must be six feet long in the abutments; the pilasters project only one half brick from the face of the wall, which increases in thickness as it gets lower. On the imposts, and immediately over those pillars, the iron girders rest, whose ends are made flat to lie upon the stone. The girders are curved, and have a versed sine of about two feet six inches. Their form and dimensions are specified in Drawing, No. 9. Each girder must be of the best No. 1 iron, and they must be proved with a weight of not less than forty tons. Groined cross arches are sprung from one

girder to the other the whole length of the bridge, and they must be well set in Roman cement. Two round wrought-iron bolts, of not less than two inches diameter, must pass from the front girder through three cross arches, and be firmly keyed in, as shown on Drawings, Nos. 9 and 10.

The four girders for the faces of the bridge will be different in their construction from the others, and will be flat on the top to receive the stones which form the projecting string course. An ornamental cast-iron front will be bolted to each of these girders.

For particulars of materials and workmanship, see General Directions hereinbefore given.

The Contractor will be furnished with Drawing, No. 10, pointing out the houses intended to be taken down for the erection of this bridge, and he will be held responsible for any damage that may accrue to any other than the so-specified houses, during the progress of the works. The lines AB, BC, CD, and EF, shows the length of railing which the Contractor has to erect in Granby Street.

BRIDGE UNDER STANHOPE PLACE.

Plate VIII.

This bridge will be built at a part of the Railway marked on the Plan Drawing, No. 2, where the excavation will be about eighteen feet in depth. The faces will consist of stone, and the internal structure of brickwork. The foundation will be of concrete, one foot thick, projecting six inches from the footings, but flush with the neat work behind, as shown in the Drawing, No. 12.

The pier and face of the abutments will consist of a series of brick pillars and pilasters, with arches and inverts sprung between them, as shown on the above-mentioned Drawing. The actual abutments shall be recessed as likewise shown thereon, and set on concrete. In case the Contractor should at any time excavate too much earth, he must fill in the extra excavation with concrete at his own expense. The stone imposts will be continued throughout the whole length of the bridge.

Each arch will be a segment of a circle, with a chord twenty-five feet long, and with a versed sine of two feet six inches. The torus moulding must run the whole width of the bridge, and no stone can be used in it less than four feet in length. The parapet will be of stone, with stone pillars of the dimensions shown in the Drawing, and the whole coped with stone.

The drains must be laid in Roman cement.

For particulars of materials and workmanship, see General Directions hereinbefore given.

BRIDGE FOR CRESCENT PLACE.

This bridge will be built at a part of the Railway marked on the Plan Drawing, No. 2, where the excavation will be about twenty-one feet deep. The voussoirs, faces of the pier and abutments, the facing of the plinth, the string course, dentels, and coping will be of stone. The spandrells, parapets, and other parts of the face of the work, of malm bricks, tuck pointed, and the internal structure of good sound brickwork. The actual abutments are solid; in other respects this bridge resembles that at Stanhope Place, to which the Contractor is referred.

BRIDGE OR COVERED WAY UNDER PARK STREET.

Plate VIII.

This bridge crosses the Railway at a part marked on the Plan Drawing, No. 2, where the excavation is about twenty-two feet deep. It will be built on an inclination of 1 in 132, but the soffit will not be

parallel with the rails, being three feet higher above the line of the rails at the south end than at the north. The cross arches will not be groined, but the spandrells must be carried up from the girders as shown in the Drawing, and the arches will then spring level for their whole width; in every other respect the Specification for the bridge under the Hampstead Road will apply to this bridge. The same stipulation will apply to the houses in Park Street, as to those in the Hampstead Road—viz., that the Contractor must be answerable for any damage done to any other houses than those tinted with Indian ink on the Plan Drawing, No. 2.

BRIDGE OVER THE REGENT'S CANAL.

Plates IX. and X.

This bridge is to be erected at a part of the Railway, marked on the Plan Drawing, No. 2, at or near to the termination of this Contract. The Railway at this place crosses the Regent's Canal at an angle, slightly askew, but the bridge will be built square. The height, from the top water level of the Canal to the level of the rails is thirteen feet, and the clear distance between the abutments fifty feet.

The bridge will consist of three main ribs, of cast-iron, properly secured and bolted together. Each main rib will be composed of two ribs, properly connected, and each of these will be cast in one piece. The cross girders will be secured to those ribs, and the thrust of the arch sustained by tie-bolts. The open and ornamental work of the face will be bolted to the main ribs, as shown in Drawings, Nos. 21 and 22. The roadway plates will be fixed as shown in Drawing, No. 22, and they will be perforated for drainage. No ballasting will be laid on the bridge. The chairs will be fixed on oak blocks, firmly secured to the girders. Coffer-dams will have to be sunk by the Contractor at his own expense, in order to get in the foundations of the abutments, and are to be included in the amount of his Tender. Concrete will be employed in these foundations, as shown in the Drawings. The abutments will principally consist of brickwork, set in mortar (except so much as is included between the foundation and the level of one foot above top water level) for eighteen inches from the face of the work, which must be set in Roman cement. The abutments will be faced with stone, and stones will have to be built and bonded in, in various parts, as shown on the Drawings.

PILING AND COFFER-DAMS.

The Contractor shall provide and drive cast-iron piling to protect the sides or banks of the canal in the parts directed by the Engineer. This piling must be set down in the Schedule of Prices, to be provided and driven at so much per foot, and the Contractor will be paid at this rate for such quantity of piling as the Engineer shall see fit to give him written orders to drive; the piling is shown in Drawing, No. 20. In commencing this bridge, the Contractor must, in the first instance, proceed to place a coffer-dam round the intended site of the south abutment, of sufficient dimensions to contain the whole of the foundations described in the Drawings, and well and conveniently to erect the same. He will be at liberty to withdraw the piling after the completion of the abutment, unless the Engineer should see fit to order it to be driven lower than the top of the concrete, shown on the Drawings, in which case the Contractor is required to cut off such piles level with the bottom of the Canal. In case the Engineer should think fit to increase the length of the piles, the Contractor shall be bound to provide and drive them of such length as the said Engineer may order, and is to be paid for the same at the rate contained in the Schedule of Prices. When the south abutment shall have been raised so high as the Engineer may direct, the Contractor shall drive the iron piling for the new towing-path,* which must be all driven, and the new towing-path made good, before they shall proceed to excavate the foundation of the north abutment.

Drawing, No. 21, gives an elevation and sectional view of the main ribs. They will be of best No. 1 pig iron, and each main rib will consist of two portions connected by means of bracing frames, each of

* In the execution of the work, a retaining wall, as shown in our Engraving, Plate IX., was substituted for the cast-iron piling at first proposed.

these consists of a segmental arch of fifty feet span, and five and a quarter feet versed sine or rise. The depth of this arch will be twenty-four inches perpendicular at the crown, and eighteen inches at the springing. Uprights of about two feet eleven inches from centre to centre, and nine and a half inches wide, connect this arch to a longitudinal bar below and another above. The whole of this is to be cast in one piece. Two of these ribs are joined together by bracing frames, shown in Drawing, No. 22, which also carry the girders by means of suspension-bolts. The space between the two portions of the main rib is covered by iron plates, as shown on Drawing, No. 21. On the top of the rib is bolted an ornamental band, composed of intersected circles, and capped with a small torus. This band is to be cast in lengths corresponding to those between the bracing frames or every other upright, so that it breaks joint between them. An ornamental band, similar to the upper one, but composed of larger circles, is placed below the lower longitudinal bar of the rib, and bolted to the bracing frames. A fillet and cavetto connect the circular work to a large torus, which serves to conceal the tie-bolts. The circular work, fillet, cavetto, and torus, are to be cast together in pieces of the same length as those of the upper ornamental work, and each of these pieces is firmly bolted to two bracing frames. The main tie-bolts are each composed of three pieces; the couplings are shown on Drawing, No. 22. They are keyed into a boss cast upon the rib, as shown on Drawing, No. 22. There are two of these tie-bolts to each outside main rib, and four to the centre one.

The girders are suspended, as hereinafter named, to the bracing frames, by two and a quarter inch wrought-iron bolts; they consequently extend from rib to rib, and the oak blocks which carry the chairs are to be firmly bolted on the tops of them, as shown on the Drawing. The roadway plates consist of a lattice one inch thick, composed of one inch square bars, three inches from centre to centre. They are fixed as shown in Drawing, No. 22. Three thicknesses of patent felt are to be interposed between the bracing frames and girders, one thickness between the bracing frames and main rib, where the chipping-pieces are shown in the Drawing, and one thickness between each girder and the oak block fastened on the top thereof. No bolt holes are to be cast in the ribs or girders, but are to be carefully drilled out afterwards to fit the bolts. The mortices in the tie-bolts must not be cut until the bolts have been fitted in their places and accurately marked.

ABUTMENTS.

Drawing, No. 20, represents the foundations of the bridge, and construction and alteration of the towing-path. One half of the plan shows the foundations and towing-path, the other is taken above the stone course lying on the concrete, and shows the method of cramping it together. The abutments are shown in plan, section, and elevation, on Drawings 20 and 22.

Piles, twelve inches square and eight feet long, are to be driven at the points noted on the Plan of foundations, and iron bolts are to be keyed to them, connecting the said piles with the iron piling, in order to hold the latter in its proper place. The bolts are all of the same length, and the points where the piles are to be driven are situated so, that the bolts form portions of *radii* of the curve in which the piling is fixed.

The chairs which carry the rails are fixed on the oak blocks on the top of the girders throughout the whole space between the abutments. Over the abutments they are fixed on oak beams, which rest on the abutment wall, and extend for twenty feet from the face of the work, so as to ease the rails in case of the settlement of the embankment. The rails over the bridge are wrought-iron bars, six inches by two and a quarter. They are fixed on chairs of the construction shown on Drawing, No. 22, over the bridge, and on those generally used on the line afterwards.

In the whole process of the construction, erection, and completion of the bridge, as well of its various parts, the Contractor must strictly observe the forms and dimensions of the Drawings, nor shall he in anywise deviate from them in the slightest respect, unless in compliance with the written orders of the Engineer. The Contractor is also bound to execute the whole of the work in a sound, thorough, and workmanlike manner, and no part of the work shall be allowed to pass without the special approval of the Engineer. The iron must be cast, wrought, tested, and fitted in compliance with his injunctions. The order he prescribes must be attended to in the fixing and erecting the several parts, and the Contractor

shall at once provide, at his own expense, all labour, machinery, and implements deemed necessary by the Engineer for the furtherance of the work. Each girder must be tested to forty tons, and each tie-bolt to sixty-five tons. For all particulars not contained in this part of the Specification, the Contractor is referred to General Stipulations hereinbefore contained.

BALLASTING AND LAYING THE PERMANENT WAY.

The Railway throughout this first Contract is intended to form a fourfold way, composed of single lines of rails. The direction of each portion of the line where the rate of inclination changes is shown upon the Plan Drawing, No. 2. The greatest care will be required that the portions shown upon the Plan Drawing, No. 2, as straight, shall be perfectly so upon the ground, and that the curves are all uniform and properly brought into the straight lines. The laying and ballasting of the permanent way is intended to be completed in such portions, and at such times, as the Engineer shall direct.

Previous to the delivery of the materials of the permanent way to the Contractor, the surfaces of the embankments and the bottoms of the excavations shall be made at the proper heights and depths, and uniform in width, level, or inclination, and they shall be completely drained and certified by the Engineer as being in a fit state for receiving the permanent ballasting. The materials to be delivered to the Contractor shall consist of rails, chairs, keys, pins, blocks, sleepers, and trenails; and he will be held responsible for the replacement, in case of loss or injury, of the materials thus delivered to him, from the time of their delivery until the expiration of his Contract. The rails will be in lengths of from twelve to eighteen feet. They will be supported by cast-iron chairs or pedestals, which will be accompanied by two wrought-iron keys for fixing the rail in the chair, and two spikes for fixing the chair on the sleeper or block. The sleepers will be of wood, and the blocks of stone. The dimensions of each part, and the construction of the whole, are shown in Drawing, No. 24.

The Company will reserve to themselves the right of directing whether stone blocks or wood sleepers shall be employed, or both, and if both, in what proportion or situation.

The materials for ballasting shall be composed of broken stone or clean gravel, entirely free from any admixture of clay, capable of setting hard, and not retentive of moisture. If broken stone is used, it shall not be larger than will pass through a ring of two and a half inches in diameter; the ballasting shall be spread over the whole surface of the top of the embankments and bottoms of the excavations, of an uniform thickness of ten inches where stone blocks are employed, and eighteen where sleepers are used. The stratum of ballast shall be beaten into a firm and solid mass by heavy beaters, worked by at least two men, and the thickness before mentioned, shall be considered to apply only after this operation has been effectually performed. Upon this surface the blocks or sleepers are to be laid in their proper situations for receiving the rails.

When stone blocks are used, each block shall be bedded in its proper situation by frequently lifting it by a spring lever to the height of one foot above the surface of the ground, and letting it fall forcibly on the ballasting; this operation shall be continued until no sensible difference of level is perceived. After each fall, should the block then be found too low, it shall be removed, and more material placed on its intended bed, and the above operation repeated until the block has reached its proper level, and has attained as firm and uniform a bed as can be obtained throughout the whole area of the underside of the block.

When wooden sleepers are used, the ballasting intended for the bed shall be beaten by heavy beaters, and each sleeper also forcibly beaten, when it has been placed in its position, until it has become firmly and uniformly bedded throughout its whole length, and reached its proper level. If it should be found lower than is required, it shall be removed, and additional materials placed upon its bed, the same process as before must be renewed until it has reached its proper level.

The rails must be laid at the proper level or inclination, each of them parallel, and at the same

height at any point on straight lines. On curves, the outer rail shall be laid as much higher than the inner of each respective line of way as the Engineer shall direct.

The joinings must be made perfectly even, whether square, half lapped, or scarfed, and be firmly secured in the chairs.

The two outside lines of way are to be six feet apart; the two inside, twelve feet apart; and the distance from inside to inside of the rails of each way, is to be four feet eight inches and a half apart.

The stone blocks will be delivered to the Contractor in their rough state, and he will be required to drill two cylindrical holes in each block, six inches deep, and two inches in diameter, to make the upper surface in each block perfectly level to drive the trenails, and cut off their tops flush with the surface of the blocks, and to fix the chair firmly in its proper position by means of the iron spikes, with a thickness of patent felt interposed between the chair and the block furnished him for that purpose.

The wood sleepers will be delivered to the Contractor as sawn out, and he will be required to make their upper surfaces perfectly level for the reception of the chair, which shall be fairly fixed on to the exact gauge: the pins shall not on any account be driven into the sleepers without their holes being previously bored with a proper sized auger.

The rails must be securely fixed in the chairs by two keys; the chairs shall be firmly fixed on the sleepers or blocks; the whole of the upper surface of the stone blocks must be worked to a plain surface, and a space in the centre, of sufficient size for the whole bed of the chair, must be fair tooled perfectly level, so that the chair will rest perfectly steady upon the block.

Any of the rails which may be twisted or bent in the least degree, to be made perfectly straight with proper hammers and anvils previous to their being laid down.

The Contractor shall in no case remove any material, excepting the soil hereinbefore specified, from the intended sites of any of the embankments, unless permitted by the Engineer.

The Contractor shall also be at the whole expense of purchasing and obtaining gravel or stones for the purpose of ballasting, whether brought from the adjoining lands or otherwise.

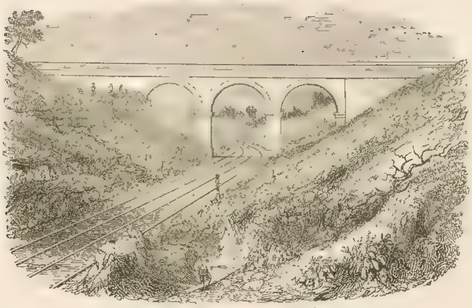
Brick or tile drains throughout the excavations are to be laid in the ballasting, as shown in Drawings, Nos. 24 and 25.

From the Depot to the Hampstead Road, and under each bridge, a double drain shall be laid, and a single drain throughout the remainder of the excavations, as shown in the Plan Drawing, No. 2.

There shall be cross drains every thirty feet, and a sink-trap with iron gratings to each alternate cross drain.

The main drains must be properly and securely laid with moulded bricks, set in mortar. The joinings and intersections of the drains shall be carefully attended to; should the Engineer choose to employ four-inch draining tiles instead of these drains, he is at liberty to do so.

The Contractor shall give the Assistant Engineer a receipt, stating the number of rails, or other materials, on each parcel being delivered to him; and after they are placed in his possession, he shall be accountable for the loss of any part of them. He shall also replace any rails, chairs, keys, trenails, blocks, or sleepers which may have been broken or otherwise rendered unfit for use while in his possession.



LONDON AND BIRMINGHAM RAILWAY—HARROW IN THE DISTANCE.

SPECIFICATION

Of the several Works to be done in making and completing a Part of the London and Birmingham Railway.

EXTENT OF CONTRACT, AND GENERAL STIPULATIONS.

This Contract commences at the Depot, near the intersection of the Hampstead Road with the Regent's Canal, and terminates at the River Brent, including a length of about five miles and three-quarters.

It comprehends the following works:—The making of the temporary fences necessary during the progress of the other works: the making of the permanent fencing: the formation of the whole of the excavations and embankments: the raising of the land for the proposed Depot: making and completing the tunnels under Primrose Hill, and the London and Harrow Road, near Kensal Green: the erection of the bridges over the Railway, at the crossing of the private road from Paddington to Hampstead; at the crossing of the London and Edgeware Road, near Kilburn; at the crossing of the Railway over the road to Wormwood Scrubs, called Mitre Lane: and at the crossing of the Railway over the road from Haleston Green to Acton: the making and completing of the approaches to each of the foregoing bridges: the erection of the bridge over the River Brent: the making of the culverts under the Railway for the Serpentine River and Canal feeder, and all other culverts shown on the section; and laying and ballasting of the permanent way, including the providing of all timber, bricks, lime, stone, or other materials necessary for the completion of the works; the iron-rails, chairs, keys, pins, trenails, blocks, and sleepers for the purpose being provided by the Company.

EXTRA WORKS.

The erection of gates, the excavation and embanking of sloped occupation bridges, the metalling of occupation roads, the paving of roads crossing the Railway on a level: the building of occupation bridges and culverts, laying and ballasting permanent sidings, and the formation of tool recesses, are considered as extra works, and will be paid for as such according to the Schedule of Prices for extra works set out in the Tender.

The preceding enumerated works, and the mode of execution, are described at length in the Specification of each particular work, and their forms and dimensions described in the accompanying Drawings, which are referred to in each Specification; but should any discrepancies exist between the

measurement by the scale attached and the written dimensions, the same is to be referred to the Engineer, whose decision shall be conclusive; anything contained either in the Drawings or Specification shall be considered as contained in both. The written dimensions are those by which it is intended the Contractor shall make his estimate.

EXCAVATIONS AND EMBANKMENTS.

The part coloured red in the Plan, shows the direction of the Railway, and the area of land which will be purchased by the Railway Company, and upon which the Contractor shall have full permission to erect any temporary houses, offices, &c., necessary during the execution of the works, or any machinery for excavating, embanking, or tunnelling, provided that such proposed erections shall not be specially prohibited by the Act for making the Railway. The embankments are coloured light red, and the excavations of a deeper red.

The red line on the section describes the tops of the embankments, and the bottoms of the excavations, previous to the laying and ballasting of the permanent way.

The black undulating line describes the present natural surface of the ground along the centre line of the Railway, showing the respective heights of the embankments, and depths of the excavations, from which data their contents have been calculated, on the supposition that the area of any cross section in side-long ground does not differ from the area of a similar section in level ground.

The levels, from which the section is made, are believed to be accurate, but the Contractor must verify the results, as he will be held liable to the consequences of any errors.

EMBANKMENTS.

The whole of the embankments in this Contract shall have slopes of two to one (that is to say), where the base of the slope is two feet, its height shall be one foot only; and they shall be thirty-three feet wide at the level of the red line in the section, neither more nor less.

Each of the embankments shall be uniformly carried forward as nearly as the finished heights and width as the due allowance for shrinking of the materials will admit of, and this allowance shall not exceed or fall short of the quantity deemed necessary by the Engineer. In all cases, this must be carefully and strictly attended to, in order to avoid the necessity of making any subsequent addition, either to heights or the width of the embankment, to bring them to their proper level and dimensions.

The surface of the embankment shall be kept in such form, or be intersected by such drains, as will always prevent the formation of pools of water upon them, and ensure the embankment being kept as dry as possible.

Whenever the material teemed over the end of the embankment shall not form the proper slope, it shall be carefully trimmed to its required form, and this operation must proceed at the same time with the end of the embankment, so as to obviate the necessity of any future addition of material to the sides of the embankment.

As the embankments advance, and become consolidated, the slopes shall be carefully trimmed into planes having the proper slope, and be neatly covered with an uniform substance of turf, of not less than eight inches in thickness, and laid with the green sward outwards; the turf must be taken from the ground to be occupied by the base of the embankment, and cut square, so as to be laid on the slopes in the form of flags; and where the land is arable, the slopes of the embankment shall be covered with the soil. It must be uniformly laid on of the thickness of six inches, and sown with rye-grass and clover seed, as soon as the proper season will admit of its being done, not less than one pound and a half of clover seed, and one pound and a half of rye-grass seed, to be sown on each acre.

When the material brought to the embankment consists of large lumps, they shall be broken into pieces of not more than six inches in diameter.

EXCAVATIONS.

The excavations in this Contract shall be thirty-three feet wide at the level of the red line on the section. Between Chalk Farm Lane and the private road from Paddington to Hampstead, the slopes shall have three feet base for every foot in height, and from the last-mentioned place to the termination of the Contract, the slopes shall have two feet base for every foot in height.

The slopes of the excavation shall be finished as the cutting advances, and be neatly and uniformly dressed to the specified inclination, as near to the face of the cutting as possible. As soon as any part of the slopes are dressed to the proper inclination, they shall be covered with turf taken from the land to be occupied by the excavations, in the same manner as before directed in the Specifications of the embankment; and when turf cannot be obtained, the slopes must be covered with soil, and sown with rye-grass and clover seeds, as before directed in the Specifications of the embankment.

Whenever and wherever springs, soaks, or streams of water may appear, and ssue from the face of the slopes, the Contractor shall be bound to make and maintain, during the progress and until the completion of the works, such drains or water-courses as shall completely and effectually prevent the said springs, soaks, or streams of water from injuring the slopes, and shall convey the whole of such water into proper drains, so that none shall be permitted to lodge in the excavation; and where beds of sand, gravel, or other loose mould occur, the face of the slope must be protected from the injurious effects of such springs or streams of water by any other means that may be advisable or necessary.

At the bottom of each slope a drain of an uniform depth below the rails, as shown in the Drawings, shall be made, and these drains must be continued on both sides under all the bridges which cross the Railway. A drain shall also be made at the top of each slope, so as to exclude from the excavations any water draining off or flowing from the land; and all covered or open drains which may be intersected by the excavation, must be made to discharge their water into the ditch at the outside of the top of the slope, for which purpose the said ditch shall be made as deep at least as the bottom of the intersected drain, and the space between the outside drain and the slope shall be well puddled at the point of intersection. The Contractor shall also be compelled to open or make any new drain which the Engineer may deem necessary for the exclusion of any water from the Railway excavations.

In the formation of the excavations and embankments, the Contractor must provide, at his own expense, all the necessary rails, chairs, keys, pins, blocks, and sleepers, as well as waggons, barrows, planks, or other machinery, materials or utensils, which stipulation is however modified to a certain extent by the following conditions:—It is not intended to deliver to the Contractor any of the permanent rails, chairs, keys, pins, blocks or sleepers, until the completion of at least one continuous mile of roadway, which distance must be certified by the Engineer as being ready for the reception of the permanent ballasting, in which case a sufficient number of rails, chairs, keys, pins, blocks, and sleepers, shall be delivered to the Contractor, who will be permitted to use them in such manner only as is hereinafter described in the Specification of the ballasting and laying of the permanent way.

FENCING AND DITCHING.

The fencing and ditching described in the following Specifications is of two kinds; the first temporary, for the protection of the lands adjoining the Railway during the progress, and until the completion of the works; the second permanent, for the enclosure of the Railway when finished.

TEMPORARY FENCING.

Immediately after the delivery of any portion of the site of the intended Railway into the possession of the Contractor, and previous to the commencement of the other works, the temporary fencing shall be completed, and shall include the whole area of land occupied by any of the works contained in the Contract. The temporary fencing shall consist of split oak posts, placed nine feet apart, and three and a half feet high above the ground, morticed for the reception of three horizontal oak or larch rails, which are also to be supported by an intermediate stay or prick post firmly nailed to each of the rails. The whole of this fencing must be firmly and substantially fixed, so as to exclude sheep, pigs, and all cattle from the excavations and other works, and effectually prevent the adjoining lands from trespass during the progress of the works.

All drains or alterations, or deviations in existing drains or water-courses, necessary either for the exclusion of water from the cuttings, or for the prevention of damage to the adjoining property, or any other whatever, shall be made by the Contractor, at his own expense.

PERMANENT FENCING.

The permanent fencing is of two kinds, as follows: —

First.—Wood railing extending from Chalk Farm Lane to the Depot.

This portion of the fencing is to be made with oak posts and rails, constructed in the manner shown in the Drawing. The wood railing is to be placed on both sides of the Railway, on the edge of each slope at the top of the embankment. The posts and rails shall be of good oak, free from sap, and straight grained. The rails, and so much of the posts as are seen above ground, shall be sawn out square, and neatly planed to the proper dimensions. Each post shall have four mortices passing completely through it, and shall stand four feet above the level of the rails. The posts are to be placed six feet apart, and each rail shall be equal in length to two spaces or twelve feet, passing through every alternate post. The ends of the rails must be fitted exactly into the mortices of the posts, and secured with small oak trenails. The bottom of every post shall be well charred before fixing in the ground; all the joints must be made with white lead, and the whole of the wood above the ground painted with two coats of stone-coloured paint.

At the bottom of the slopes of the embankment a ditch shall be made, as shown in Drawing, for the purpose of carrying off the water draining from the slopes, which must be continued to the nearest drain by which the drainage of the adjoining fields is at present effected.

The whole of the fencing must be made at such times as may be directed by the Company's Engineer.

Second.—Brick walls, extending from Chalk Farm Lane to the beginning of Primrose Hill Tunnel, and from the other end of the same tunnel to the bridge under the London and Edgeware Road, at Kilburn.

This fencing shall consist of brick walls at the bottom of the cuttings on each side of the Railway, twenty-six feet apart equidistant from the centre of the Railway, and running parallel to the rails. The walls shall be made of the same dimensions and form shown in the Drawing. The height, exclusive of the coping, shall be three feet above the upper surface of the rails.

The footings shall be carried at least one foot below the bottom of the ditch; and if the ditches shall have been made deeper than directed, then the footings shall be carried as much lower as the Engineer may deem necessary, and this additional depth shall be made by the Contractor at his own expense. Holes, as represented in the Drawing, must be left in the bottom of each wall, to allow the water to drain freely from the ballast of Railway. The walls are to be finished with a stone coping of Bramley Fall or Derbyshire stone, six inches in thickness, and projecting one inch beyond each side of the walls. The

brickwork is to be built with good sound and well-burnt grey-stocks, laid in good mortar, made with Merstham or Dorking lime and clean sharp sand, in the proportion of three measures of sand to one of lime. The lime is to be slaked and screened with the sand, both in a dry state, and well tempered with water afterwards. The brickwork is to be flushed in solid, with mortar laid with a neat close joint, and no joint of mortar to exceed one quarter of an inch in thickness. The outside joints are to be neatly drawn.

The drains or ditches between the walls and the bottom of the adjoining slopes must be made as shown in Drawing, and kept open until the whole of the works are completed. Quick fencing and ditching, extending from the bridge under the Edgeware road and London road to the River Brent, excepting the space occupied by the tunnel under the London and Harrow road, near Kensal Green. This part of the fencing is to be placed within the limits of fifteen feet from the termination of the slopes. A ditch of six feet wide at the top, two feet wide at the bottom, and two feet deep, shall be made on the higher side of the ground to be occupied by the Railway, and a ditch of three feet wide at the top, one foot wide at the bottom, and one foot deep on the lower side of the ground. The outside of the ditch must be five feet distant from the boundary of the land occupied by the Railway, and if the last-mentioned ditch shall be deemed insufficient in any particular case, the larger sized ditch shall be made instead. The material excavated from the ditch shall be used to form a mound, both sides of which shall be neatly faced with turf. When the material excavated from the ditch shall be more in quantity than sufficient to form the mound, the surplus must be conveyed to the nearest embankment.

The best portion of the vegetable soil excavated from the ditch shall be placed in the middle of the mound, on which a double row of good three-year quicks, two years transplanted, shall be planted, and not less than twenty-four quicksets shall be contained in one lineal yard. On the inner edge of the ditch, oak posts and rails must be fixed to protect the quicks. The posts are to be of split oak, seven feet in length, and equal at least to five inches by three inches and a half in sectional area; they are to be placed at a distance of nine feet from centre to centre, and to stand three feet and a half above the top of the quick ground. Each post is to have three mortices for the reception of the ends of the rails, to be made of split oak, and to be as nearly of a uniform size as possible. The horizontal rails, three in number, between each pair of posts are to be of split oak or larch, equal to three inches and a half, by one inch and a half in sectional area, and ten feet in length, and the ends are to be scarfed so as to fill the mortices of the posts. Midway between the posts, an oak or larch stay, five feet long, three inches wide, and one inch and a half thick, is to be firmly nailed to each of three horizontal rails with good tenpenny nails.

The posts must be firmly fixed in the ground, the ends of the rails driven firmly into the mortices of the posts, and a piece of new hoop-iron, one inch and a quarter wide, shall be nailed round the top of every post to prevent its splitting. The fencing shall be made with as few bendings as the nature of the ground will admit of, and the ditch alongside of the mound shall descend as uniformly as possible to the nearest main drain or water-course, by which the drainage of the adjoining lands is at present effected.

The permanent fencing shall proceed as rapidly as the progress of the other works and the nature of the season will admit of. Such parts of the temporary fencing as can be made available, shall be permitted to be used in the permanent fencing, provided the material be of the requisite strength and quality, and uninjured in other respects by its previous use. At the bottom of the embankments small draining tiles shall be laid through the quick mound, at intervals of not more than one hundred yards, in order to convey the water draining from the slopes into the fence ditches.

Such parts of the permanent fence as shall have been completed before the finishing of the other parts of the work, shall be kept in complete order by the Contractor. The quicks shall be cleaned or weeded twice at least a year, and any broken rails, or posts, or stays replaced by new ones, equal in quality to those originally used. All the quicksets which may not take root and grow must be pulled up, and three-year old living quicksets, similar to those before described, planted in their stead.

PRIMROSE HILL TUNNEL.

LONDON ENTRANCE.

Description of the Frontispiece.

The style of composition is that generally called Italian, and was selected as admitting bold features, expressive of the strength by which Railway works should, it is presumed, be characterized.

The general design consists of a centre and wings, raised upon a rusticated basement. The centre is the archway of the tunnel, surmounted by a block cornice, and flanked by two massive square piers. The precise form of the tunnel does not appear on the face of the entrance, being modified for the sake of architectural propriety, by gradually widening out the curved side walls, until they become vertical, and form abutments for the semicircular arch.*

The wings are the retaining walls, which support the sides of the excavation at the tunnel's mouth; they curve outwards, on each side of the centre, in quadrants, the basement and plinth being continued parallel to the Railway, until the slope of the excavation renders a retaining wall unnecessary.

The only brickwork appearing on the face, is between the counterforts in the circular portion of the wing walls, which are built battering (the counterforts being plumb), and faced with Suffolk bricks. The stone is principally from the Bramley Fall Quarries, in Derbyshire.

The details will be understood on reference to the Engraving. As this, however, does not give dimensions, a few are added below:—

	Feet.	*Inches.*
Span of Arch	23	9
Height from Rails to springing	9	6
" " crown	21	6
" " crowning member of Central Cornice	35	0
" " apex of Great Pier	43	2
" " crowning member of Cornice—Circular wings	31	9
Extreme width of level ground between straight portion of wings	97	0
Extreme projection of Central Cornice	5	0
Projection of Great Piers beyond spandrells of Arch	6	0
Width of Great Piers above basement	11	0

SPECIFICATION.

This tunnel commences in the Eaton College Estate, 550 yards from Chalk Farm Lane, and terminates near the road leading from Saint John's Wood to Finchley. The length is equal to fifty and one-fifth statute chains; the other dimensions, situation, and construction of the several parts, are minutely described on the Plan and Section of the line, and Drawings.

The area of ground on the top of the tunnel to which the Contractor must confine his operations on the surface, is one statute chain wide for the whole length of the tunnel, which must be fenced off on both sides with temporary fencing.

All the General Stipulations in the Specification respecting the extension of land, &c., must be considered applicable to this part of the Contract, where no special directions are given.

The tunnel is to be made with a circular brick arch and curved side walls, resting on stone footings or skew backs, the whole being supported by a brick invert or counter-arch. The ends will be made with curved brick walls, as shown in the Drawings.

* The precise form of the tunnel and its dimensions are shown at Plate XVII

A cast-iron plate is to be let into the arch near the end, and connected by bolts to another plate built into the arch, one hundred feet distant from the first.

MATERIALS. --The whole of the bricks used in the construction of the tunnel shafts and end shall be sound, good, hard, well-burnt grey-stocks; the freestone used shall be Bramley Fall, or other stone equally good, perfectly sound, and free from flaws.

The cast-iron and wrought-iron must be of the best quality, and subject to any examination the Engineer may deem necessary. The mortar used in the tunnel shall be made from the best fresh-burnt Merstham lime, or other lime which the Engineer may deem equally good; it shall be ground in its dry and unslaked state, under hedge stones. The sand must be sharp clean sand, and shall be mixed with the lime in the proportion of three of sand to one of lime.

The lime and sand must be intimately mixed, and worked with a proper quantity of water in a pug-mill, as required for use.

The Contractor shall sink four shafts, and no more, on the centre line of the tunnel, at convenient distances; they shall be eight feet in diameter within the brickwork, which shall be of one brick in length; each shaft shall be of the same diameter, from the top to the bottom perfectly cylindrical, free from bulges and other distortions; the brickwork shall be laid in two half-brick rings, with the joints properly broken, and flushed in solid with mortar. The bricks must be moulded to fit the circumference of the shaft; where each intersects the top of the arch of the tunnel, a cast-iron curb or ring, of the same diameter as the shaft, shall be inserted in the brickwork of the arch, and upon it the shaft must be built. No wood curbs will be permitted to be built in the brickwork of the shafts.

Where any water may occur in sinking, it must be completely excluded from the shafts or tunnel by a lining of puddle behind the brickwork of the shafts, or by laying the brickwork in Roman cement, or by the adoption of any other means the Engineer may judge expedient or necessary.

The arch and side walls are to be two bricks thick, the invert one brick and a half thick throughout the whole length of the tunnel, except in cases where the material through which the tunnel will pass may, in the opinion of the Engineer, require either a greater or less thickness of brickwork in the arch, side walls, or invert.

In all such cases the Contractor shall make the brickwork of such thickness as the Engineer may direct, the Contractor being paid for any increase in the quantity of brickwork or excavation, and making any allowance to the Company for any decrease at the rate stated in the Schedule.

The invert or counter-arch, of whatever thickness it may be, shall be carefully laid and bonded; the side walls shall be laid in English bond; the arch, if one brick and a half thick, shall be built in three several half-brick rings; if two bricks thick, in four half-brick rings; and so on, each ring containing five courses of bricks more than the inner one immediately preceding it. The footings or skewbacks of the side walls shall be made of Bramley Fall stone, of the sectional form shown in the enlarged Drawing, and in lengths of not less than three feet; they shall have a bed of brickwork extending from the inverted arch, as shown in the Drawing. The skewback must be carefully bedded in the brickwork in its proper position.

The mortar in which the brickwork is set shall be as little in quantity, and as uniform in thickness between the joints, as is consistent with making the arch, side walls, and invert, firm and solid throughout. The horizontal courses must be kept perfectly straight in the direction of the tunnel, and parallel with the surface of the rails.

Should at any time the regular continuity of the arch or side walls be destroyed, either from the irregular shrinking of the arch, or imperfect fixing of the centres, or any other cause whatever, the Contractor must remove and amend the irregularities in a satisfactory manner.

Wherever water may occur and flow into the tunnel, and it shall be deemed expedient by the Engineer to lay any part of the brickwork in Roman cement, the Contractor shall be paid for so doing such an additional sum per rod of 306 cubic feet as may be stated in the Schedule of Prices.

Excavation.—The Contractor shall be at liberty to make an open cutting at each end of the tunnel, not exceeding twenty yards in length, nor wider than the outside of the brickwork of the tunnel. The sides of the excavation shall be supported and kept open by suitable timber, in such a manner as to prevent slipping, until the whole of the brickwork is completed in that length. The open space shall then be filled up to the original surface by layers of clay, of not more than one foot thickness, each of which shall be carefully punned before laying on the succeeding layer. The soil or turf must be laid aside before making the excavation, and neatly replaced when filled up. The excavation shall then proceed in the usual way, under the surface.

In no case shall the excavation be carried more than six feet in advance of the brickwork; and should any deterioration or change in the strata occur, which may appear to the Engineer to require this distance to be reduced, the Contractor shall regulate this distance by the direction of the Engineer.

In making the excavations, great care must be taken that they do not in any way exceed the area necessary for the reception of the brickwork, and the vacant space, if any, between the sides or roof of the excavation and brickwork shall be filled with clay, and rammed in solid with proper beaters, so as to avoid any distortion in the form of the tunnel from irregular pressure.

The foundation for the reception of the invert or counter-arch shall be cut out to the exact form and depth required, before any part of the brickwork is laid; and should any unavoidable irregularity be found to exist, it must be made up with dry clay or clean gravel, firmly rammed by beaters.

The whole of the material excavated, excepting that required to back the arch, whether taken from the shaft or either end, shall be conveyed into the proposed depot, and disposed of in the same way as the excavation marked No. 1 in the section. No material shall be taken out of the end near St. John's Wood Road, unless specially directed by the Engineer.

In the execution of this part of his Contract, the Contractor shall provide all the necessary materials and machinery for executing the same; make all the necessary shafts, bore holes, and perform every operation necessary for completing the work in the manner intended by the Specifications, and all the machinery, centering, &c., must be constructed in such manner as the Engineer may approve.

All air shafts which it may be necessary to make, shall be made in the same manner as the larger shafts, and stand upon cast-iron curbs of proportionate shape and dimensions.

Any drainage to the land by the falling of the surface during the execution of the work, shall be paid for by the Contractor.

Marks or signals will be, from time to time, given to the Contractor by the Company's Engineers, for the purpose of regulating the direction and level of the tunnel; and the Contractor shall be at the expense of erecting any temporary or permanent marks or signals which may be considered necessary for giving the direction and levels with the required accuracy.

Whenever the faces of the excavations between two adjoining shafts, or shaft and end, shall have approached within fifty yards of each other, the Contractor shall drive a heading from the one to the other.

The slopes of the land over the ends of the tunnel are to be made at the same inclination as the side of the excavation adjoining. A ditch must be cut round the top, similar to that at the top of the adjoining slopes, and joined thereto.

The slope must be made with puddle four feet in depth at the base, and carried in at same level twelve feet, and made up to the surface.

A cast-iron drain, as shown in Drawing, is to be laid in the bottom of the tunnel, midway between the two railways, and through the whole length of the tunnel. The connexions of the several pieces must be properly and accurately made, and the drain must communicate with the side drains of the excavation, by two cast-iron side branches at each end.

BRIDGE OVER THE RAILWAY AT THE CROSSING OF PRIVATE ROAD FROM PADDINGTON TO HAMPSTEAD.

Plate XII.

The road above mentioned crosses the Railway at a point where the excavation is about four feet in depth, requiring the road to be raised to the height of twenty-two feet and a half above the level of the Railway.

The footings of the abutments will be made eighteen inches below the level of the red line in the section, and each abutment will be strengthened by a counterfort placed at the back.

The arch will be an ellipse, having above it a projecting band of brickwork, surmounted by a stone string course; upon this will be placed the parapet wall, with a brick plinth, and surmounted by a stone coping.

The ring walls extend into the embankments of the approaches, and their foundations must be made at least as low as is shown in the Drawings.

Abutments.—The form and dimensions of the abutments are shown at A A A A, Figures 1, 2, 3, and 4; their faces will be perpendicular, their thickness being diminished from the bottom to the top by half brick offsets at the back. The abutments must be built in a solid and substantial manner.

Counterforts.— The counterforts must be built in the situation and of the form and dimensions shown at B B in the Drawings. The courses shall be laid as shown, at right angles to the drift of the arch; they must be built in a solid manner, properly bonded into the substance of the abutments.

Arch.—The arch will be of an elliptical form, as shown at C C; it must be altogether constructed of whole bricks, laid in such manner as the Engineer may direct.

As many courses as shall be included in four feet on each side of the top of the arch, shall be laid in the best Roman cement, and with straight picked bricks.

The remainder of the arch shall be laid in mortar with a close joint, and the soffit of the arch neatly pointed after the removal of the centres.

The bricks in the face of the arch shall be rubbed on their faces, and neatly pointed; great care must be taken in the proper summering of the bricks in the arch, and any irregularity of form from imperfections in the laggings or centre, shall be removed and amended by the Contractor.

Backing.—The brickwork forming the backing D D of the arch, shall be laid in a solid and substantial manner, each brick properly breaking joint with the next, in the same manner as the outside work.

Wing Walls.—The wing walls E E are to be built of the form and dimensions shown in the Drawing; battering both on the outside and inside, and the courses to be properly bonded with the abutments.

H

Spandrell Walls.—The spandrell walls F F are to be of the form and dimensions shown in the Drawing; to be well bonded with the backing, and the bricks neatly cut to fit the curve of the arch.

Parapets.—The parapet walls G G are to be of the lengths and dimensions shown in the Drawing; the courses are to be run straight the whole length, and the sides of walls to be parallel and fair.

String Course.—A stone string course, as shown in the Drawing, shall extend the whole distance between the outsides of the two abutments. The string course on the walls shall be of brick laid in Roman cement, and the upper arises of the bricks rubbed off.

Coping.—The coping H H is to be of stone of the form shown in the Drawing. No stone shall be less than three feet in length. The coping shall run the whole length of the parapet wall, and be laid perfectly straight. The stones shall be dowelled together with iron dowells, fixed with lead. All the faces of the copings and strin course are to be fair tooled, and if required rubbed in their front faces.

The spaces between the brickwork and side excavation for containing it, shall be filled up with clay as the work advances, and firmly rammed in with proper beaters. The space between the wing walls shall be filled to its proper height, and clay laid in layers of one foot in thickness, and each layer well punned before adding the succeeding one; the whole of the clay shall be filled in up to the surface before removing the centres.

MATERIALS.

Bricks.—The bricks are to be hard, sound, and well-burnt grey-stocks, of uniform size and colour for the fronts.

Mortar.—The mortar shall be made from the best fresh-burnt Merstham or Dorking lime and clean sharp sand, screened together, both in a dry state, in the proportion of one measure of lime to three of sand. They must be intimately mixed, and well tempered with a proper quantity of water.

Roman Cement, where directed to be used, shall be of the best quality, recently made, mixed with an equal quantity of sand, and only mixed when required for use.

Stone.—The stone shall be good Bramley Fall, or other similar stone equally good, free from flaws and iron shot.

General Clause.—The walls, &c., shall be laid either in Flemish or English bond, as the Engineer may direct, and in no case shall any point of mortar exceed one quarter of an inch in thickness. No broken bricks will be permitted to be used, either externally or internally, unless absolutely necessary as closers, nor shall any difference be made in the goodness of the workmanship of the interior or exterior of the work.

The whole of the brickwork shall be well grouted at every course.

The parapet and string courses shall not be made until after the removal of the centres.

All the centering must be such as shall be approved of by the Engineer, and in no case shall the centres be struck before his permission has been obtained.

EXTRA OR CONTINGENT WORKS.

Fence Gates.—The fence gates are to be made of the form and dimensions shown in the Drawing. The heels and heads are to be of good oak sawn out to the proper dimensions, and morticed for the reception of the horizontal bars.

The horizontal bars are to be five in number, of cleft-oak, and smoothed over. The ends must fit the mortices of the heels and heads, and be secured by oak pins. The diagonal braces are similar to the bars, and to be firmly nailed to the bars, the nails to pass through both, and their points clenched. The posts to be of oak, the top sawn to the dimensions and form, with a small cap on each; the bottom of the posts must be charred. The gate irons shall be of the form shown, and shall not weigh less than fourteen pounds per set. The gates must be firmly fixed in the line of the quicksets, and the wood railing neatly joined to the gate posts. The gates and posts must be painted with two coats of white or stone-coloured paint.

EXCAVATIONS AND EMBANKMENTS OF SLOPED OCCUPATION ROADS.

These excavations and embankments are to be made in the same manner as those on the line of Railway, and with such slopes as may be directed. The contents of the excavation shall be conveyed to the nearest embankment or spoil bank. The embankments are to be made from the surplus materials in the excavations; when made to form the approaches to a bridge, they must be carefully punned in between the wing walls.

METALLING OCCUPATION BRIDGES.

This is to be done in the same manner as described in the Specification of the approaches to bridges.

PAVING CROSSINGS.

All the roads crossing the Railway without bridges are to be paved in the manner shown in Drawing, with good six or seven inch paving, of Aberdeen, or other granite equally good. The paving must be laid on a bed of fine clean gravel of twelve inches in thickness, in a solid and substantial manner. The paving stones must be cubes as nearly as possible. Each rail must be protected by two iron bars, as shown in the Drawing; they will be considered part of the rails, and provided by the Company.

OCCUPATION BRIDGES.

These bridges will be similar in form and construction to the bridge at the crossing of the private road from Paddington to Hampstead; the same directions will apply to the workmanship and material in both.

CULVERTS.

The culverts are to be built in the same manner as those previously described in the former part of the Specification; they are to be built of the forms and dimensions shown in Drawing, the sizes being selected to suit the particular situation.

LAYING AND BALLASTING PERMANENT SIDINGS.

The sidings are to be laid in such positions and of such lengths as may be directed by the Engineer. They must be laid in the form and manner shown in the Drawing. The Contractor will be required to take up any part of the rails already laid that may be found necessary; to cut them into proper lengths for the reception of other iron work, to relay them, and to fix all the necessary crossing plates, check rails, moveable points, or sliding rails, with the requisite machinery for moving them.

The whole must be made equally as firm and substantial as the other parts of the permanent way.

The Specification of the permanent ballasting already described must be considered equally applicable to the construction of the sidings.

LONDON AND BIRMINGHAM RAILWAY WATFORD TUNNEL

COLNE VIADUCT,

PLATE XIII.

AND BRIDGE OVER EXCAVATION SOUTH OF WATFORD TUNNEL.

PLATE XV.

These fine designs and superior examples of masonry require but little to explain the practical details of their construction; the plans, elevations, and sections, given in the Plates, together with the details of masonry given in the foregoing Specifications, and which are alike applicable to every similar construction on this magnificent line of Railway, will give to the practical Engineer every information he may require.

WATFORD TUNNEL.

SPECIFICATION.

This tunnel commences in the Merton College Estate, in the township of Cashio, in the parish of Watford, and terminates in the estate of the Earl of Essex, in the parish of Lees or Abbott's Langley; the length is seventy-eight statute chains. Its other dimensions, precise situation, and the construction of its several parts, are minutely described, delineated, and set forth in the Plan and Section of the Railway, and in Drawings, Nos. 40 and 41. The area of ground above the tunnel, to which the Contractor must confine his operations on the surface, is one statute chain in width for the whole length of the tunnel. The whole space along the top of the tunnel, one chain in width, is to be fenced off on both sides with the temporary fencing, which must be made to unite with the other fences, either temporary or permanent, at the ends of the tunnel. These temporary fences are to be removed after the completion of the tunnel, and no permanent ones to be erected in their stead. All the general stipulations in the Specification, with respect to the extension of land, &c., are applicable to this part of the Contract, where no special directions are given.

The tunnel is to be composed of a brick arch nearly semicircular, supported by curved side walls standing on stone footings or skewbacks, which are to rest on the counter or inverted arch, forming the base of the tunnel. The ends of the tunnel will be made with wing walls, as shown in the Drawings.

A cast-iron plate is to be built into the arch, near the mouth of the tunnel, and connected by bolts to a second similar plate built into the arch, one hundred feet distant from the first plate.

MATERIALS.

All the bricks used in the tunnel, the mouths of the tunnel, wing walls, and all the shafts, must be good, sound, well-burnt, hard grey-stocks. The freestone shall be Bramley Fall, or other stone equally good, perfectly sound and free from flaws. The cast-iron and wrought-iron must be of the best quality. The strength of the wrought-iron bolts and their couplings must be proved by their being subjected to a strain of twenty-five tons each before being used in the tunnel.

The mortar to be used in the tunnel shall be made with the best fresh-burnt Merstham or Dorking lime, or other lime which the Engineer may deem as equally good. It shall be ground under edge-stones, in its dry or unslaked state. The sand must be sharp clean sand, and shall be mixed with the lime in the proportion of three measures of sand to one of lime.

The lime and sand must be well mixed and worked, with a proper quantity of water, through a pug-mill, as required for use.

The Contractor shall sink six working shafts on the centre line of the tunnel, at convenient distances. They shall not be less than eight feet diameter within the brickwork, which shall be of the thickness of one brick length.

Each shaft shall be of the same diameter from top to bottom, perfectly cylindrical, free from bulges and other distortions. The brickwork shall be laid in two half-brick rings, with the joints properly broken and flushed in solid with mortar. The bricks must be moulded to fit the circumference of the shaft.

Where each shaft intersects the top of the arch of the tunnel, a cast-iron curb or ring of the same diameter as the shaft shall be inserted in the brickwork of the arch, and upon which the shaft must be built. No wood curbs will be permitted to be used in the brickwork of the shafts.

The Contractor must sink an air shaft at the distance of fifty yards on each side of each working shaft, unless the said distance of fifty yards shall fall in any road, in which case, the air shaft must be sunk as near thereto as practicable.

The Contractor will be at liberty to sink as many other air shafts as he may think proper. The diameter of these shafts must not be less than three feet six inches within the brickwork. At their intersection with the brickwork of the arch of the tunnel, they must stand upon cast-iron curbs, exactly similar to those specified for the working shaft; and the air shafts must, in every particular, except as to their diameter, be made in the manner hereinbefore specified for the working shaft.

After the completion of the tunnel, the brickwork of the working and air shafts must be carried up to a height of ten feet above the surface of the ground, and finished with a coping stone six inches thick at the inner circumference, and four inches and a half at the outer circumference. The width of the coping is to be fifteen inches, projecting one inch on the outside of the brickwork, and throated.

When any water may occur in sinking, it must be completely excluded from the shafts or tunnel by a lining of puddle behind the brickwork of the shafts, or by laying the brickwork in Roman cement, or by the adoption of any other means which the Engineer may consider necessary.

The arch and side walls are to be two bricks thick; the invert, one brick and a half thick throughout the whole length of the tunnel, unless the stratum through which the tunnel shall pass should, in the opinion of the Engineer, require either a greater or a less thickness of brickwork in any part of the walls of the tunnel.

Whenever required so to do, the Contractor shall make the brickwork of the tunnel, in any part thereof, of such thickness as the Engineer may direct.

The Contractor is to be paid for any increase in the quantity of brickwork or excavation, and he is to be charged for any decrease at the rate specified in the Schedule.

The counter-arch or invert, of whatever thickness it may be, shall be carefully laid and bound. The side walls shall be laid in English bond.

The arch, if of the thickness of one brick and a half, shall be built or composed of three several half-brick rings; if of the thickness of two bricks, it shall be built or composed of four several half-brick rings, and so on, and each half-brick ring shall contain five courses of bricks more in number than the inner one immediately preceding it.

The footings or skewbacks of the side walls shall be made of Bramley Fall stone, or other stone equally good for the purpose, and of the sectional form shown in the Drawing. The length of each stone must not be less than three feet. There must be a bed of brickwork under the stone footing or skewback, extending from the inverted arch, as shown in the Drawings. The skewback must be well bedded in the brickwork.

The mortar used in the brickwork shall be as little in quantity, and as uniform in thickness between the joints, as is consistent with making the work firm and solid throughout.

The longitudinal courses must be laid perfectly straight, in the direction of the tunnel, and must be parallel in every direction with the surface of the rails.

If at any time before the termination of the Contract, the regular continuity of the brickwork of the tunnel should be destroyed, arising either from irregular shrinking or settlement of the arch, or imperfection in the centres, or any other cause whatsoever, the Contractor must remove and amend the irregularities in a satisfactory manner.

Whenever water may occur or flow into the tunnel, and it may be deemed expedient by the Engineer to lay any part of the brickwork in the best Roman cement, the Contractor shall be paid for so doing such an additional sum per rod of 306 cubic feet as may be stated in the Schedule of Prices.

EXCAVATION.

In no case shall the excavation be carried more than six feet in advance of the brickwork; and should any change in the strata occur, which may in the opinion of the Engineer require the distance to be reduced, the Contractor shall regulate the distance by the directions of the Engineer.

In making the excavations, great care must be taken that they do not exceed the area necessary for the reception of the brickwork; but such may unavoidably be the case. The vacant space between the sides or roof of the excavation and the brickwork of the tunnel shall be filled in with chalk, broken small and rammed in hard and solid with beaters, so as effectually to prevent any distortion in the form of the tunnel from irregularity of pressure.

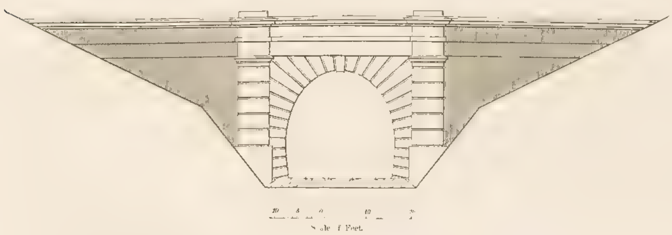
The foundation for the reception of the invert or counter-arch shall be cut out of the exact form and depth required, before any part of the brickwork of the corresponding portion of the tunnel shall be laid; and if any faulty places shall occur in the chalk or other stratum forming the floor of the excavation, the faulty places must be made good by being filled up.

Whenever the faces of the excavations, carried on by means of two contiguous shafts, shall approach within fifty yards of each other, the Contractor shall then drive a heading quite through, and join the workings, before he proceeds with the erection of any more of the brickwork of the tunnel.

No shaft whatever will be permitted to be sunk in any public or private road which may cross the line of the tunnel.

About 1700 yards of the excavation from the tunnel will be required for the embankment over the Colne Valley, and the whole of the remainder will be required for the embankments beyond the north end of the tunnel; all the material which shall be excavated from the tunnel, whether brought out at the ends or taken up the shafts, must be conveyed into the embankments at the ends.

In the execution of this part of his Contract, the Contractor shall provide all the necessary materials and machinery for executing the work; make all the necessary shafts, bore holes, and perform every operation necessary for completing the work in the manner intended in the Specifications. All the machinery, centerings, &c., must be constructed in such manner as the Engineer shall approve. Any damage done to the land by the falling of the surface during the execution of the work, shall be paid for by the Contractor. Marks or signals will from time to time be given to the Contractor by the Company's Engineers, for the purpose of regulating the direction and level of the tunnel; and the Contractor shall be at the expense of erecting any temporary or permanent marks or signals which may be considered necessary for giving the direction and levels with the required accuracy. The slopes of the ground over the ends of the tunnel are to be made at an inclination of one to one, and a ditch must be formed at the top, similar to those at the tops of the excavations, and must communicate therewith. The slope must be made with puddle, as shown in the Drawing. A cast-iron drain, as shown in the Drawing, is to be laid in the bottom of the tunnel, midway between the two lines of Railway, and through the whole length of the tunnel. The connexions of the several pieces must be properly and accurately made, and the drain must communicate with the side drains of the excavations by two cast-iron side branches at each end.



NORTHCHURCH TUNNEL.

PLATE XVII.

THIS tunnel commences in the field marked No. 34 on the Plan, and terminates in that marked No. 38, being about sixteen chains in length.

The Contractor is to confine his operations to the width of one statute chain upon the surface of the ground over the intended tunnel; and, previously to commencing any part of the said tunnel, the above width is to be fenced in with temporary fencing, similar to that hereinbefore described, which must be made to unite with the fencing along the line of the Railway.

This fencing is to be removed after the completion of the tunnel, and no other fencing erected, excepting over the ends, where permanent fencing, similar to that hereinbefore described for the sides of the Railway, must be erected.

This tunnel is to consist of a brick arch, of the form shown in the Drawings, supported by curved side walls, standing upon stone skewbacks, which are to be bedded upon the counter or inverted arch, forming the base of the tunnel. This invert is to be one brick and a half in thickness, excepting at the shaft, as shown in the Drawing, and the arch and side walls are to be two bricks thick throughout the whole length of the tunnel, excepting for a length of seven feet three inches at the front, and a distance of twelve feet on each side of the shaft, together with the shaft length, where they will be three bricks thick, or in such other places as the Engineer may consider it requisite to make them thicker; in which latter case the Contractor shall be paid for the increase according to the rate mentioned in his Schedule of Prices.

The arch, if of the thickness of one brick and a half, shall consist of three half-brick rings; if it be two bricks thick, it shall consist of four half-brick rings, and so on; and each ring shall contain five courses of bricks more than the ring immediately beneath it.

The bricks to be made use of in that part of the arch between the points C and D, Drawing, No. 17, Fig. 2, are to be moulded taper, so that the sides may radiate agreeably to the curvature for that distance. All the rest of the bricks may be of the ordinary shape.

The whole of the brickwork is to be set in mortar, excepting that part on each side of the shaft which is marked on the Drawing, to be set in Roman cement; but if the Engineer should think it necessary to have any other portion set in cement, the Contractor shall be paid for the difference of cost at the rate set forth in his Schedule of Prices.

The longitudinal courses of brickwork must be laid perfectly straight in the direction of the tunnel, and must be parallel in every direction with the surface of the rails; and if, at any time before the termination, the regular continuity of the brickwork of the tunnel shall be destroyed, either in consequence of irregular shrinking or settlement of the arch, or imperfection of the centres, the Contractor shall amend or remove such irregularity in a satisfactory manner.

The stone skewbacks of the side walls shall consist of stone of the quality hereinbefore described. No stone must be used less than three feet in length. There must be a bed of brickwork under the stone skewback extending to the inverted arch, in which the stonework shall be soundly bedded.

Shafts.—The Contractor may sink two working shafts on the centre line of the tunnel, at such places as the Engineer shall direct. They shall be nine feet diameter inside the brickwork, and the brickwork shall be of the thickness of one brick's length. The shafts shall be of the same diameter from top to bottom, perfectly cylindrical, free from bulges, and all other imperfections. The brickwork shall rest upon a cast-iron curb, fitting into the crown of the arch of the tunnel, forming a level base for the shaft to rest upon.

The bond shall be of whatever description the Engineer may require. The shafts shall be carried up to a level, ten feet above the level of the surface, and finished with coping of Bramley Fall stone, nine inches thick, and fifteen inches wide; and the stones shall be dowelled together, and run in with lead, the dowels being not less than four inches long. Wherever any water may occur in sinking the shafts, it must be excluded from it by a lining of puddle behind the brickwork, or by setting the brickwork in Roman cement, or both, if necessary. The Contractor must also sink two other shafts on the centre line of the tunnel, one at each end of it, and drive a heading, four feet wide and five feet high, throughout the whole length of the tunnel. This heading must be carried through before any part of the main tunnel is commenced, and must be supported and kept open, during the execution of the whole work, by such timbering or other means as may be deemed necessary by the Engineer.

The Contractor will be at liberty to sink whatever air shafts he may think proper, provided they in no case come within fifty yards of the working shaft. They are to be three feet diameter within the brickwork

and supported at their intersection with the arch of the tunnel on cast-iron curbs. The Specification for the working shaft, in regard both to these curbs and the workmanship and materials, must be considered equally applicable to these shafts.

A brick drain, as shown upon Drawing, No. 17, must be constructed throughout the whole length of the tunnel. The brickwork is to be laid in mortar as hereinbefore described.

Excavating.—In excavating the tunnel, the Contractor shall not in any length advance beyond the completed brickwork more than six feet without the special permission of the Engineer; and should the nature of the ground at any time render it unsafe or inexpedient to advance so much as six feet with the excavation beyond the brickwork, the Contractor shall limit such advances as may be directed by the Engineer.

The space excavated in advance of the brickwork, shall be carefully and substantially supported by the usual modes of timbering, viz., by sills, props or shores, bars and polling boards; the dimensions and arrangement of such timbering to be approved by the Engineer.

The invert, sides, and roof must be cut out as nearly as possible of the finished size of the exterior of the brickwork; and in any case where the bottom may have been taken out beyond the stipulated dimensions, the excess must be made perfectly sound and good before the brickwork of the invert is commenced, by being well filled up with suitable material.

Wherever any space exists between the exterior of the brickwork and the excavation, whether on the sides or roof, arising either from the required size of the excavation being exceeded, or from the withdrawal of the bars, the greatest care shall be taken to pun the same perfectly solid with suitable materials, as the brickwork advances in height; and in no case shall the brickwork rise more than two courses without this operation being effectually performed.

When the bricklayers are getting in the side walls and turning the arch, one labourer at each face must always be employed by the Contractor to do nothing else but to pack the brickwork, by ramming in small chalk behind the walls with an iron rammer. And in case the Contractor should neglect or refuse to employ a man at each face for that purpose only, the Engineer shall have the power to do it, and to charge the Contractor with the expense.

In the upper portion of the arch, where the bars cannot be drawn, or the operation of punning or packing performed until the brickwork is completed, the operation shall be proceeded with as soon as the succeeding length of excavation shall have advanced so far as to admit of its being soundly and effectually performed from the end, by beaters of a suitable construction; and should the nature of the material through which the tunnel may at any time be advancing be so unsound as to render the drawing of the bars and planking likely to affect or disturb the brickwork, either in its form or stability, such portions of the said bars and planking shall be left, as may be deemed necessary by the Engineer.

None of the sills made use of, excepting those in the first length in the shaft, shall be allowed to penetrate into or rest upon the brickwork in the side walls, but shall be supported by means of tressels resting upon the invert, and quite independent of the side walls. The holes formed by the sills in the said first lengths, shall be made good with brickwork laid in Roman cement, immediately on the sills being withdrawn.

In the executing of this (as in every other) part of the Contract, the Contractor must find all the necessary materials and machinery for executing the work, make all the necessary shafts, bore holes, and perform every operation necessary for completing the work in the manner intended by the Specification. All the machinery, centering, &c., must be constructed to the satisfaction of the Engineer.

The material excavated from the tunnel must be conveyed to form the embankments in this Contract.

Marks or signals will be given to the Contractor from time to time by the Company's Engineers, for the purpose of regulating the direction and level of the tunnel; and the Contractor shall be at the expense of erecting any temporary or permanent marks or signals which may be considered necessary for giving the direction and levels with the requisite accuracy.

Iron.—The cast-iron of the curbs, shown in Drawing, No. 17, must be of the best No. 2 iron; the castings free from air bubbles and perfectly sound, and the bolts and nuts must be of the best scrap-iron.

Tunnel Fronts.—The fronts of this tunnel are shown in Drawings (see Vignettes to this article).

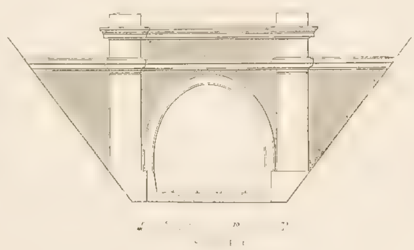
Drawing, No. 15.—The arch of the tunnel ends in stone quoins two feet deep on the face, and toothing into the brickwork alternately three feet and four feet six inches; they project from the face to the extent of three inches. The corners or arrises thus formed must be neatly chamfered, and great care must be taken to make the joints close and accurate without flushing or flaw of any kind.

Pilasters of solid brickwork, faced with stone, break forward from the general front on each side of the arch. They are crowned with caps of stone; and the same form of moulding is carried along between the pilasters, and also on the tops of the side walls. The arch and pilasters are surmounted by a frieze, cornice, and blocking course. On the pilasters the frieze will be of brick, faced with stone to the depth of one foot six inches, and two feet three inches alternately, whilst that over the arch will be entirely of brick. The cornice will be of solid stone throughout, and all the mouldings must be cut sharp and clean. The blocking course over the arch will consist of stone, whilst that over the pilasters will be of brick, faced as before-mentioned with stone; it must also be closed in at the top with stone, the joints of which must be laid in Roman cement, so as completely to exclude water. The whole of the stonework must be fair tooled, and the joints made true and accurate.

A brick drain runs along at the back of the tunnel front, and connects with other drains down the slopes of the cutting, as shown in the Drawing, No. 16. This drain is to consist of nine-inch brickwork laid in Roman cement, and it must be embedded in a mass of concrete of the extent shown on the Drawing.

Drawing, No. 16.—The Specification for the tunnel front just described, must be considered equally applicable to this in every thing which is common to both. The arch of the tunnel ends in stone quoins, which tooth into the brickwork alternately two feet six inches and three feet six inches. The whole front is faced with stone, excepting the side walls and a part of the parapet or frieze over the arch, which are of brick. The pilasters batter on the face, as shown at Fig. 3, and the side walls batter at the same rate, being set back nine inches.

A drain, as previously described, laid in cement and bedded in concrete, runs along the foot of the slope behind the tunnel front, and connects with other drains down the slopes of the excavation. In these fronts, wherever the brickwork appears, it must be faced with white Cowley bricks.



OBLIQUE BRIDGE OVER ROAD

FROM LONDON TO BERKHAMPSTEAD ON BOX MOOR.

Plate XVI.

The Railway intersects this road at an angle of 32°, and at a point where the height of the level of the rails above the surface of the present road is twenty-three feet seven inches.

The arch is a segment of a circle twenty-one feet span on the square, and five feet nine inches rise. The bridge is to be of brick, excepting the impost or skewbacks, the voussoirs or quoins of the arch, the string courses and copings, which are to be of stone. The whole of the exterior face is to be built with white Cowley bricks.

Arch.—The arch is to be of brick two feet six inches thick. The voussoirs are to be two feet six inches in depth at the crown, and two feet nine inches at the springing, and are to tooth into the brickwork of the arch twelve inches; the mean length of the voussoirs on the soffit to be four feet and three feet alternately, but the absolute length of the voussoirs to be increased from the obtuse angle to the acute angle, under the direction of the Engineer; the joints are to be chamfered both on the face and soffit of the arch. The courses must run in a spiral direction, and the skewbacks must be accurately cut, with faces at right angles to the spiral lines.

The corners or arrises of the voussoirs, together with the acute angle of the abutment, are to be cut off in the manner, and to the extent shown in the Drawing, Figs. 1, 3, 4.

Abutments.—The abutments are to be of the form and dimensions shown on the Drawings. The courses of that part resting on the cross arches, and forming the backing of the arch, are to be inclined, and the bricks cut and worked into the substance of the abutment, so as to make the best possible bond. For particulars of materials and workmanship, see General Directions hereinbefore given.

The Contractor must prepare and keep in order during the time of building the above-mentioned bridge, and until the centering is removed, a temporary road round the end of the bridge, not less than twenty feet in width. For the description of such temporary road, and the restrictions to which he is liable in regard to it, the Contractor is referred to the Specification of "Approaches to Bridges."

The following particulars of this fine specimen of an oblique arch has been obligingly communicated to us by G. W. Buck, Esq., the Resident Engineer, by whom the bridge was erected:—

This bridge, which is commonly called "Box Moor Skew Bridge," carries the Railway at the height of twenty-three feet seven inches above the level of the turnpike-road; and the angle at which the road and Railway intersect each other is 32°. This degree of obliquity is believed to be greater than elsewhere previously attempted in brickwork or masonry. The square span of the arch is 21 feet, and the oblique span 39·627 feet.

The arch is a segment of a cylinder, the thickness of which is two and a half feet, and the internal radius twelve and a half feet; consequently, the versed sine is 5·718 feet, which, by the nature of oblique bridges, becomes the rise of the arch for the above span of 39·627 feet. The angle at which the coursing joints in the soffit, or intrado, of the arch cross the axis of the cylinder is 53° 25′; also, the angle at which they cross on the extrado is 58° 15′, and the difference or 4° 50′ is the angle or "*wind*" of the bed of the voussoirs. By reference to the elevation, it will be observed, that the joints of the face of the arch all converge to one point, which in this case is 32·54 feet below the axis of the cylinder, or 45·04 feet below the crown of the arch. This curious property of the oblique arch, which, so far as I know, I have been the first to notice and to make practically useful, will be fully treated of, and the method of computing its position given, in my forthcoming work on oblique arches, which is now nearly ready for the press.

When stone or brick is cut to a very acute angle, as in this bridge, the quoins are not only difficult in execution, but are unavoidably broken off, either in setting, by settlement, or by accidental blows. In order to get rid of this objection, so much of the acute quoin is cut off at right angles to the face of the arch as gives the bridge the appearance of having another voussoir. Thus, in this case, the actual number of voussoirs in the arch is thirty-four, but, in consequence of this artifice, the apparent number is thirty-five. The quantity thus cut off from the acute quoin is gradually diminished to the opposite or obtuse quoin, where the cutting vanishes. Thus not an angle less than a right angle is presented on the surface of any part of the work. The new intradoral line thus obtained is a segment of a larger ellipsis, and the effect produced is elegant and pleasing to the eye.

BLISWORTH EXCAVATIONS AND EMBANKMENTS.

Plates XX. to XXXVII.

Of this interesting and important work we have given exact copies of the Contract Drawings, to the full size and scale; and in order to render them still more interesting and useful, we have had our coloured copies also completed in the same style and manner. Plates 20 to 29 contain a copy of the working section, plotted to a scale of one inch to four chains horizontal, and one inch to twenty feet vertical. The depth of the ballasting, including the height of the rails, is shown by the two parallel lines, representing the gradients, and between which the rates of inclination are marked. The lower of these two lines, and which, in the following Specification, is called the blue line, describes the tops of the embankments and bottoms of the excavations previous to the laying and ballasting of the permanent way, consequently the upper line of the two represents the upper surface of the rails.

SPECIFICATION.

The part coloured red on the Plan Drawing, No. 2, shows the direction of the Railway, and the area of the land which will be purchased by the Railway Company, and upon which the Contractor shall have full permission to erect any temporary houses, offices, &c., necessary during the execution of the works, or any machinery for excavating or embanking, provided that such proposed erections shall not be especially prohibited by the Act of Parliament for making the Railway.

The blue line on the Section Drawing, No. 1, describes the tops of the embankments and the bottoms of the excavations previous to the laying and ballasting of the permanent way. The uncoloured space on the section below the blue line represents the embankments, and the space between the blue line and the surface shows the excavations. The black undulating line describes the present natural surface of the ground along the centre of the line of the Railway, showing the respective heights of the embankments and depths of the excavations, from which data their contents have been calculated, on the supposition that the area of any cross section in side-long ground does not differ from the area of a similar section in level ground. The levels and other admeasurements from which the section is made are believed to be accurate, but the Contractor must verify the results, as he will be held liable for the consequences of any error. Cross sections of a cutting and embankments, with drains, fences, &c., are shown in Drawing, No. 19.

EMBANKMENTS.

The whole of the embankments in this Contract shall have slopes of two to one, that is to say, when the bases of the slope is two feet, its perpendicular height shall be one foot only, and they shall be thirty-three feet wide at the level of the blue line on the section, neither more nor less, which width shall extend equally on either side of the outside rails after they shall have been laid and completed as hereinafter described. Each of the embankments shall be uniformly carried forward as nearly at the finished heights and widths as the due allowance for the shrinking of the materials will admit of, and this allowance shall not exceed or fall short of the quantity deemed necessary by the Engineer. In all cases this must be carefully and strictly attended to, in order to avoid the necessity of making any subsequent addition, either to the heights or widths of the embankments, to bring them to their proper level and dimensions. The

surface of the embankments shall be kept in such form, or be intersected by such drains, as will always prevent the formation of pools of water upon them, and ensure the embankments being kept as dry as possible. Whenever the material teemed over the end of the embankments shall not form the proper slope, it shall be carefully trimmed to its required form, and this operation must proceed at the same time with the end of the embankment, so as to obviate the necessity of any further addition of materials to the sides of the embankment.

As the embankments advance and become consolidated, the slopes shall be carefully trimmed into planes having the proper slope, and be neatly faced or ramped with a uniform covering of turf of not less than eight inches in thickness, and laid with the greensward outwards. The turf must be taken from the ground to be occupied by the base of the embankments, and where the land is arable the slopes of the embankments shall be covered with the soil. It must be uniformly laid on of the thickness of six inches, and sown with rye-grass and clover seeds, as soon as the proper season will admit of its being done; not less than one pound and a half of clover seed and one pound and a half of rye-grass seed to be sown on each acre. When the materials brought to the embankments consists of large lumps, they shall be broken into pieces of not less than six inches in diameter, unless they consist of rock.

EXCAVATIONS.

The excavations throughout this Contract shall, when turfed or soiled, be thirty-three feet wide at the level of the blue line on the section, neither more nor less, and shall extend to an equal distance on each side of the outside rails, except in certain parts of the Excavation, No. 5, where retaining walls are inserted, in which case the widths are variable, and the Contractor is referred to the Drawing and Specification of that part of the line. (See Drawings, Nos. 3, and 4.—Plates XXX. to XXXVII.)

The excavations in this Contract are five in number, and are designated in the sections as Nos. 1, 2, 3, 4, and 5. (Plates XX., XXII. to XXVI.)

Trial shafts have been put down in all the excavations to ascertain the nature of the materials to be excavated, and the nature, thickness, and relative positions of the beds of clay, marl, shale, limestone, &c., are shown in the Section, No. 1, (Plates XX. to XXIX.) which it is believed correctly represents the extent and quality of the materials to be cut through, but it remains with the Contractor to verify the correctness of the section, as he will be held liable to the consequences of any alteration in the continuity of the strata between the shafts. The shafts have been left open for examination; the materials obtained in sinking them may be seen at the top of each shaft, and samples of the various strata sunk through may be seen on application at the Railway Office, at Weeden.

As soon as any part of the slopes, not having less base than one foot and a half to every foot in height, are dressed to the proper inclination, they shall be covered with turf taken from the land to be occupied by the excavations, in the same manner as before directed in the embankments; and where turf cannot be obtained, the slopes must be covered with soil, and sown with rye-grass and clover seed, as before directed in the Specification of embankments.

In the formation of the excavations and embankments in this Contract, the Contractor shall not remove the turf or soil from the ground for a greater distance than half a statute chain in advance of the face of the excavation or embankment, and that which has been cut must be removed back to a point where the slope is ready for receiving it, and laid down as directed with as little delay as possible.

Whenever and wherever springs, soaks, or streams of water may appear, and issue from the face of the slopes, the Contractor shall be bound to make and maintain, during the progress, and until the completion of the works, such drains or water-courses as shall completely and effectually prevent such springs, soaks, or streams of water from injuring the slopes, and shall convey the whole of such water into proper drains, so that none shall be permitted to lodge in the excavation; and where beds of sand, gravel, or other loose mould occur, the face of the slope must be protected from the injurious effects of such springs or streams of water by any other means that may be deemed advisable or necessary by the Engineer.

At the bottom of each slope a drain of a uniform depth below the rails, as shown in the Drawings, shall be made, and these drains must be continued on both sides under all the bridges which cross the Railway. A drain shall also be made at the top of each slope so as to exclude from the excavations any water draining off or flowing from the lands adjoining; and all covered or open drains which may be intersected by the excavation, must be made to discharge their water into the ditch at the outside of the top of the slope, for which purpose the said ditch shall be made as deep at least as the bottom of the intersected drain, and the space between the outside drain and the slope shall be well puddled at the point of intersection.

The Contractor shall also open or make any new drain which the Engineer may deem necessary for the exclusion of any water from the Railway excavation.

In the formation of the excavations and embankments, the Contractor must provide, at his own expense, all the necessary rails, chairs, keys, pins, blocks, and sleepers, as well as waggons, barrows, planks, or other machinery, materials, or utensils, which stipulation is however modified to a certain extent by the following conditions: —

It is not intended to deliver to the Contractor any of the permanent rails, chairs, keys, pins, blocks, or sleepers, until at least one continuous mile of roadway, together with 300 yards in continuation at each extremity of such mile, shall be certified by the Engineer as being ready for the reception of the permanent ballasting, as in this Contract is hereinbefore mentioned; on which certificate, a sufficient number of rails, chairs, keys, pins, blocks, and sleepers shall be delivered to the Contractor by the Company, and he shall be permitted to use them in such manner only, as is described in the Specification of the ballasting and laying of the permanent way, provided however that such permanent rails shall in no case whatever be laid down and employed within 300 yards of the face of any excavation, or the end of any embankment then in progress.

From the shafts that have been sunk in the Cutting, No. 5, (Plates XXIV. to XXVI.) it is expected that a considerable quantity of stone will be found sufficiently hard for the purpose of blocks, such as described in the Drawings and Specification of the ballasting and laying the permanent road.

In all and every case, either in the above-named excavations or any other within the limits of this Contract where rocks exist (which, in the opinion of the Engineer, is proper for making blocks), the Contractor shall proceed in such manner as may be best calculated for obtaining blocks of the size and quality specified under the head of ballasting and laying already alluded to, and shall obey the directions of the Engineer in working such rock.

For each block so procured and delivered at the situation within this Contract where it will be used, the Contractor shall be paid by the Railway Company one shilling over and above the amount of his Tender. And should the Contractor, in any case where stone exists suitable for blocks, neglect to work it in the manner best calculated for obtaining them both sound and in the greatest quantity, he shall be liable to a deduction from the amount of his Tender, equal to the estimated value of the blocks which might have been obtained. The estimate value shall be made by the Engineer.

Wherever material occurs in any of the excavations of a quality suitable for making bricks, the Contractor shall be at liberty to make use of such material for that purpose; but if in so doing he shall cause any deficiency in the material for the formation of the embankment, he shall make up such deficiency by a side cutting, at his own expense, in such of the excavations as the Engineer may point out; and if such side cutting require an additional quantity of ground, the Contractor shall indemnify the Company for the purchase of the same.

The Excavation, No. 1, (Plate XX.) consists of clay and shale, and the sides are to be formed as a slope, having a base of two feet for one foot in perpendicular height.

The Excavation, No. 2, (Plate XXII.) consists of rubbly sandstone, limestone, and shale, and the

sides must be formed at a slope, having a base of one foot and a half for each foot in perpendicular height.

The Excavation, No. 3, (Plate XXIII.) is nearly similar as regards material to No. 2, and the sides must have a like slope of one foot and a half to each foot in perpendicular height.

The Excavation, No. 4, (Plate XXIII.) is principally soil and clay, and must have the same slope in the sides as Nos. 1, 2, and 3.

In the Excavation, No. 5, (Plates XXIV. to XXVI.) the strata are various kinds, consisting principally of a bed of limestone extending nearly throughout the excavation, which bed of limestone is overlaid by beds of clay and marle in the deepest parts of the cutting, and underlaid by a thick bed of shale throughout its whole length. The sides of the excavation must have slopes of various inclinations (hereinafter particularly described), according to the nature of the material to be cut through. From the end of the cutting A to the point B, the sides shall be taken out at a uniform slope of two feet base to one foot in perpendicular height. (Plates XXVI. and XXXVII.)

Throughout the whole of the remaining part of the excavation, all soil, clay, sand, marle, or other materials *above* the aforesaid limestone rock, shall be taken out at a slope of two feet base to one foot in perpendicular height; between the foot of which slopes and the top of the cutting in the rock, a bench of nine feet in width shall in all cases be left. (Fig. 1, Plate XXXVII.) The slopes of the cutting in the limestone rock to have three inches base to one foot in perpendicular height. Whenever the shale or other soft strata lying under the limestone is found to rise above the level of the bottom of the cutting, a portion of such shale or soft strata shall be excavated from under the limestone on each side of the cutting, and replaced by walls, buttresses, arches, and inverts, as hereinafter described. Whenever the depth or thickness of such shale or soft strata falls short of fourteen feet, the side walls shall be of the dimensions shown in Drawings, Nos. 3 and 4, and described in the Specifications relative thereto. (Plates XXXIV. and XXXV.)

To prevent any injury to the slopes by the springs of water issuing from the rock and other strata in this excavation, the strictest attention will be required on the part of the Contractor; and the modes of drainage, adapted to the varying thickness of the shale and other strata, are particularly described in the Drawings, Nos. 3 and 4, and the Specifications relative thereto.

DRAWING, No. IV.

Fig. 1, Plates XXX. and XXXI.—Represents a cross section of such excavation when the shale rises to the height of twenty-two feet above the bottom of the cutting.

A B	Is a cross section of a buttress
C D	Is a cross section of one-half of an invert.
E F	Is a cross section of the recess wall.
G H	Is a cross section of a drain in the centre of the cuttings.
I K	Represents the method of carrying off the water from behind the wall.
L M	Section of pitching between buttresses

Figs. 2 and 3, Plates XXXII. and XXXIII.—Is an elevation and plan of the retaining walls and buttresses.

A B	Plan of buttress.
C D	Plan of invert.
E F	Plan of recess wall.
G H	Plan of central drain
a	Side drains communicating with central drain by means of cross drains *b b*.
I K	Sunk drains in face of wall communicating with side drains *a a* by sunk drains *c c*.
L M	Plan of pitching between buttresses.

The inverts to be of an invariable width of twenty-seven feet, and to have a rise of three feet three

inches, the radius being twenty-nine feet eight inches, the junction of which inverts, with the face of the buttresses, to be always at the level of the surface of the rails.

The face of the buttresses in the cross section to be described by a radius of 106 feet, the radius of the square, with the face of the rock at its junction with the top of the buttress, therefore, rising three inches vertical to one foot horizontal, corresponding to the slope of the rock. (Plates XXXIV. and XXXV., Figs. 1, 4, and 8.)

The back of the buttresses to batter outwards from the centre of the cutting at the rate of three quarters of an inch horizontal for one foot in height, as shown in the section; and the sides of the buttresses to batter out at the rate of one in twenty on each side, as shown in the plan and elevation.

The recess walls to have the same batter at the back corresponding with the buttresses, and the face of such walls to have a straight batter of two inches horizontal in one foot vertical. These walls shall have three courses of footings of one foot each in depth, each course to step six inches. The bottom of the walls to be level with the bottoms of the inverts and buttresses.

The central drain to be made according to the dimensions in the plan. When it crosses the inverts, they will form its bottom, and between the inverts the bottom to be laid to a uniform inclination.

At a depth never falling short of one foot below any wet stratum that may occur, two courses of the recess wall and buttresses to be projected beyond the back of the wall; the lower course to project beyond the upper, so as to receive a stone to rise one foot above the upper course, forming a drain twelve inches deep and six inches wide, to be surrounded at the bottom and back with a casing of sound puddle, and filled in at top with rubble stone, to allow the top water to have access to the drain, as shown in the Drawings at I K. This drain to have a regular fall from the centre of each buttress, as shown by the dotted lines, Nos. 1 and 2 in Elevation Drawing, No. 4. (Plates XXX. and XXXI.)

The water, when thus collected, shall be carried through the recess wall and down the sunk channel in its face, as shown in section and elevation of Drawing, No. 4. (Plates XXX. to XXXIII.)

The pitching between the buttresses to extend from the foot of the recess walls to the side drains *a a*.

The inverts being preserved of a constant width at the level of the surface of the rails, and the face of the buttresses, being a uniform curve, proceeding from the slope of the rock at its junction with the top of the buttress, the width between the tops of any two buttresses will depend upon the depth of the shale above the bottom of the cutting, the width of the said buttress being invariably four feet at top in elevation. The same circumstance will affect the width at their junction with the inverts. The same circumstance will also affect the thickness of the recess walls and buttresses. Thus, in Fig. 3, Drawing, No. 4, (Plate XXXIII.) when the shale is twenty-two feet deep, the width between the top of the buttress is forty-one feet six inches; while, in Figs. 4, 6, and 7, Drawing, No. 3, where the depth of the shale is fourteen feet, the width is thirty-four feet two inches. (Plate XXXV., Figs. 4, &c.) This will also, in like manner, determine the width of excavation at the bottom of the rock, which, being flush with the face of the buttresses at their top, overhangs the recess wall one foot six inches.

When the depth of the shale from the bottom of the rock to the bottom of the cutting shall be less than fourteen feet, then the inverts between the buttresses shall be discontinued; and in lieu of the inverts the buttresses shall have four courses of footings, when the depth of shale above the bottom of the cutting exceeds ten feet, and three courses for all lesser depths. Further, when, as aforesaid, the shale, or clay, or other soft material rises to the height of ten feet above the bottom of the cutting, then the level of the bottom footings of the buttresses shall be three feet three inches below the said cutting, which depth shall decrease proportionally as the above height diminishes, until the rock meets the level of the bottom of the said cutting.

Where there are no inverts (*i. e.* at all depths less than fourteen feet), the distance between the tops of

the buttresses, and consequently the width of the excavation between the tops of the buttresses, shall be uniformly thirty-four feet two inches; the face of the buttresses and recess walls being determined in this case by the same rules as when the inverts exist, and the width at the top of the buttresses being constant. The width of the cross section at the level of the rails will depend upon the depth of the shale, as will be seen by referring to Drawing No. 3, Plates XXXIV. and XXXV., where it will be seen that by this means the cross section at the top of the undersetting gradually approximates in width and form to the ordinary shape of the cutting in rock.

The north-west end C of the retaining wall terminates by a buttress, and at thirty-eight feet north-west of the buttress (extending to B), the excavation, as before stated, will have a uniform slope of two feet base to one foot in height. (Plate XXXVII.)

Between the points C and B, the form of the excavation will be determined by straight lines, drawn parallel to the surface of the railway from corresponding points in the face of the cross section at C and B. Throughout this extent (from C to B) the shale beneath the rock will have a facing of masonry (commencing at C and terminating at B), as shown in Figures 1, 2, and 3, Drawing No. 3. (Plates XXXVI. and XXXVII.) The back of which retaining wall to be determined in a manner similar to the front, by straight lines being drawn from corresponding points at the back of the buttress at C, to the same at the back of the lining at B, thus lessening regularly in thickness from C to B. To render this description more easily understood, a model of the north-west end of the cutting accompanies the Plans.

MATERIALS AND WORKMANSHIP FOR WALLING.

The whole of the walls and buttresses to be of masonry, the stones to be procured from the excavations; the courses to run as thick as the material obtained from the excavation will afford when properly quarried. The facing stones to bed at least eighteen inches, the beds to be square with the face of the buttress or wall. The stones to be hammer dressed, and brought to a true though rough bed, especial care being taken to prevent too full a bearing in the centre of the bed. Their faces do not require to be smooth dressed, but rough nobbled, similar to pitching, and the joints to be rustic. If it should so happen, that after the quantity of sufficiently large stones shall have been procured to form the faces of the walls and buttresses, the excavation will not afford any of a similar description for the backing, then the said backing may be formed of rubble set in mortar, as hereinafter described, the stones composing which to be brought to a bed top and bottom, laid in courses, it being understood that the Engineer or Engineers for the time being shall have the sole option of determining the necessity of adopting and the manner of performing the rubble work. The bottom of the rock to be taken out to receive the walls and buttresses, as shown in the Plans and Sections, and stones, corresponding as near as possible with those shown in the said Section, to constitute the top of the said walls and buttresses; the stones to be accurately fitted to the rock and soundly fixed, so that for the whole depth of the said walls and buttresses, the rock shall rest upon them. The object of this arrangement being to secure a sound support to the rock, and to effect, by the dovetailed stones, a connexion with the rock, to prevent the top of the wall being pushed out.

The spandrells of the inverts and base of the buttresses to be filled with masonry in courses, and the angle made good, as shown in the Figure 1, Drawing No. 4. (Plate XXXI.)

The bottom course in all cases to be composed of stones as large as an be obtained, and the bottom bed worked true.

The bottom, at the buttresses and walls, when there are no inverts to be laid on a level bottom, the courses to be brought gradually to radiate with the wall at the top of the footings by the varying thickness of the courses, as shown in the Figures 5 and 8, Drawing No. 3. (Plate XXXIV.)

The courses of the masonry in the walls between the points C and B, at the north-west end of the walling, to correspond with those of the buttress at C, and to have the same inclination or rake. The increasing batter to be obtained by enlarging the width of the benches between the upper and lower courses

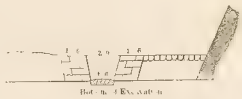
in the face of the wall. The working, setting, and mortar for this walling will be similar to that specified for the buttresses and recess walls.

The invert to consist of stones laid in regular courses, and each stone two feet in depth; the stones to be brought to a smooth bed, and radiated to the centre of the courses.

The skewback at the end of the invert to be formed so as to suit the radiating course of the invert and the buttress, and to be not less than nine inches deep on the face. The sides of the centre drains to consist of masonry according to dimensions on Plan, the interior face being fair and regular. The top to consist of an arch of brickwork set in mortar, or covered with stones if they can be procured large enough to stretch across the drain, and to bed four inches on each side between the inverts, the bottom of the drain to be pitched with stones or brick, brought to a fair face.

The side and cross drains to be formed either of brick or stone, neatly faced at the sides and bottom, and set in concrete mortar of the description hereinafter described.

The centre drain will not be required between the points H and I, at the south-east end of the cutting, and instead, the side drains *a a* will be made two feet wide at top and one foot six inches at bottom, and deepened so as to be level with the bottom of the excavations; their bottom to be pitched and finished similar to the centre drains, and the drains for the cutting between D and H to be diverted by similar drains into the above. The side walls of the above to be of stone or brickwork set in mortar, and to be one foot six inches thick, thus:



The mortar to be used in the beds and faces of buttresses, walls, sides of drains, and invert arch, to consist of one part lime to three parts of clean river or other unexceptionable sand. The sand to pass through one-quarter inch skreen; the lime to be fresh and well intermixed by a thorough beating. The mortar for running into the upright joints of the courses, and for filling in the work sound, to consist of one part lime to four parts of small unskreened gravel, to be well mixed and beat to a tough consistency, and liquified in tubs or other vessels, to be properly adapted to run into and fill up all vacuities.

The mortar to be used as hot as is consistent with the safety of the work, and the sand and gravel to be perfectly free from any loamy or other particles of a muddy nature.

The imestone rock found in the excavation may be used for the mortar specified to be used in the retaining walls in this Contract.

The pitching between the buttresses to consist of four-inch pitchers procured from the excavation, and neatly squared, their base to be four-fifths their top face, and to be laid to a uniform surface falling from the recess walls to the longitudinal drains, and filled in with grout made of mortar, similar to the face mortar previously described, only with one part lime to five parts sand.

All spaces behind the walls and buttresses, and in front of the footings beneath the ordinary bottom of the cutting, shall be filled with clay or other suitable material, thoroughly punned in; and if, through mistake or otherwise, any excavation for walls, buttresses, or inverts shall be made below the proper level, the space shall be filled up to the proper level with masonry or concrete, at the option of the Engineer.

The puddle behind the wall for preventing the water from the wet clay intermingling with the dry strata beneath, to be at least eighteen inches thick, and to consist of clay proper for the purpose, to be thoroughly worked in with the original strata of dry clay or shale.

The broken stones above not to be less than what will pass through a one and a half inch ring, and to be laid indiscriminately, without any gravel, sand, or other loose materials being intermixed in their interstices. This provision to be made wherever any wet strata shall be encountered.

Throughout that portion of the excavation where the retaining walls are required to be built, the face of the cutting shall in no case have advanced beyond the completed portion of the wall more than a length equal to the distance between two buttresses, so as to avoid the weight of the rock breaking or injuring the natural solidity of the clay or shale; and should it be found necessary, to the effecting of this object, to follow the face of the excavation with the retaining wall at a less distance than that already stated, the Contractor shall do so, or otherwise support the exposed portion of the shale by efficient shoring at his own proper cost and charge.

It will be understood, that the whole object of these precautions are to prevent the natural beds of the shale being disturbed by the pressure of the rock or dripping of water, previous to the retaining wall being completed, as already specified.

All moulds, templets, and materials that may be requisite for the due execution of the above works, are to be urnished at the charge of the Contractor.

If the Engineer or Engineers for the time being, during the execution of the works, shall see fit to extend or diminish the lengths of the walling, number of buttresses and inverts, or to alter the quantity of any excavation or other work scheduled, then a proportional deduction or addition shall be made according to the Schedule Prices; or, if any strata or fissure of clay shall occur in the limestone rock itself, then the clay or shale in such fissures shall be faced with masonry according to the direction of the Engineer or Engineers for the time being, and paid for according to the Schedule of Prices.

Throughout the whole of this cutting, the slopes of the clay and shale above the rock, and the ditching and fencing, will be executed as for the rest of the Contract. The face of the rock will not be required to be taken out to a smooth slope, but no projections or indent on its face shall exceed three inches beyond the true line of slope; and if any loose lump or mass of rock shall occur in the slope, so as to be deemed insecure by the Engineer, then the said mass or lump of rock shall be removed at the charge of the Contractor.

EXTENT OF WALLING AND EXCAVATION.

The undersetting of the rock in Excavation, No. 5, extends from the point marked D to the point marked B, in the Section No. 1, a distance of 660 yards, and also between the points marked H and I, a distance of 440 yards. Of the length between B and D, the space B to E, extending 396 yards, will require inverts in addition to the walls and buttresses; the remaining space from E to D, 264 yards in length, and also the part included between H and I, extending 440 yards as aforesaid, will only have the walls and buttresses, the inverts being omitted.

However, as the shafts only indicate at different points the depth and thickness of the various strata, such strata in the intermediate distances may not be exactly as described on the section, and any increase or diminution, over or under the quantity of work calculated from the section, will be added to, or deducted from, the amount of this Contract, according to the Schedule of Prices accompanying the Tender.

The central drain will be carried beyond the point C to the end A of Cutting, No. 5, at the same level below the bottom of the cutting as where the walling exists, and at A to be diverted into one of the side drains at the foot of the embankment.

DISPOSAL OF MATERIAL OF EXCAVATION.

The material yielded by Cuttings, marked on the Section, Nos. 1, 2, 3, and 4, to be deposited in

Embankments, marked Nos. 1, 2, 3, and 4, the remainder of the material requisite for the completion of the said Embankments 1, 2, 3, and 4, to be obtained from the Cutting, No. 5.

The Embankment, No. 5, to be formed entirely from the remainder of the material yielded by Cutting, No. 5.

In this Contract, the aggregate content of the cuttings being rather greater than the embankments, the Contractor, after having supplied the quantity requisite to form the approaches to raised occupation roads, shall be at liberty to employ any remaining redundancy for ballasting the surface of the road, provided such redundancy consist of rock or other material suitable for the purpose, and in conformity with that part of this Specification wherein the ballasting and laying of the rail is particularly described.

Throughout this Contract the cuttings consist of variable proportions of rock, shale, and marle, the Contractor will therefore be required, throughout the progress of the different excavations, to make such arrangements as will insure the rock, shale, and marle being yielded from time to time by each cutting in such proportions, and disposed of at each embankment in such manner, as will effectually secure the embankments being composed of shale and marle in the centre, with a covering of rock on the tops and slopes.

It is not intended, however, that the rock shall in any way be set by hand, but merely trimmed into a uniform slope, and covered with soil and sown with seeds, as already stipulated under the head of 'Embankments.'

KILSBY TUNNEL.

PLATES XXXVIII. TO XLVII.

The construction of this tunnel has, unexpectedly, proved the most formidable undertaking upon the whole of the London and Birmingham Line of Railway; and, in consequence of the incomplete nature of the works at the present time, it would be impossible for us to give any satisfactory account of the undertaking; we must, therefore, defer doing so till the publication of an additional volume, or supplement to the present volume, which we contemplate will soon be forthcoming, in consequence of our having been favoured with several very important works at too late a period for insertion in this volume; at which time we shall have an opportunity to supply the full details of the Kilsby Tunnel, which, upon consideration, we consider to be a better arrangement than now giving what must necessarily be a very imperfect account of this great and heavy undertaking.

The following are the subjects of our Plates:—

Plate XXXVIII.—Plan of half the tunnel front and wing walls. The road from Ashley St. Legers to Watford crosses the line of railway near the tunnel entrance. This plan will be better understood by comparing it with the longitudinal section, Plate XL.

Plate XXXIX.—Elevation of half the tunnel entrance, and one wing wall.

Plate XL.—Longitudinal section of the extremity of the tunnel, showing the iron bolts to resist the thrust in that direction.

Plate XLI.—Transverse sections of the wing walls, taken at the points marked I., II., III., IV., and V. Plan of wing wall, &c

Plate XLII.—Plan of the foundations and drainage, &c

Plate XLIII.—Half sections of the ordinary and ventilating shafts, &c.

Plate XLIV.—Sections of the entrance to the tunnel, &c.

Plate XLV.—Details of the iron curbs which support the ordinary shafts. Fig. 14·3, the iron door to shaft; and Fig. 8·3, the brick arch of the tunnel.

Plate XLVI.—Half of the ground-plan of tunnel.

Plate XLVII.—Enlarged transverse section of tunnel.

THE CHAIRS AND RAILS

ON THE LONDON AND BIRMINGHAM RAILWAY.

Plates XLVIII. to L.

These three Plates represent three of the modes in use of fixing the rail to the chair. In the course of railway experience, rails and chairs have been variously formed, but nearly all agree in principle. The most generally adopted mode at present is by making a depression on one internal side of the chair to receive a corresponding projection or fange formed on the lower edge of the rail. The rail, after being dropped into the chair, and held to the side in which the depression is formed, can be fixed in that position by driving a key or wedge between the opposite side of the rail and the chair. This mode of attachment is distinctly shown in Plate XLIX., which represents the mode of fixing the sixty-five pounds parallel rail on the London and Birmingham Railway. Another mode of fixing on the same line of railway is shown in Plate XLVIII., which represents Mr. Stephenson's method of fixing his fifty-pound rails. On the Southampton Railway, the rails and mode of fixing are similar to that on the Birmingham Line, Plate XLIX. The method of fixing the rails to the chairs on the Greenwich Railway, is shown beneath the elevation of the viaduct, Plate LXX. Those on the Croydon Railway have a continued bearing of timber, to which they are firmly fixed by screws, as shown at Plate LXXII., and which will be described with the particulars of that line of railway.

The Board of Directors of the London and Birmingham Railway Company, desirous of carrying on the great work in which they are engaged on the most scientific principles, and, if possible, to avoid the enormous cost of repairs which has attended some large works of a similar description, offered by public advertisement a prize of one hundred guineas "for the most improved construction of railway bars, chairs, and pedestals, and for the best manner of affixing and connecting the rail, chair, and block to each other, so as to avoid the defects which are felt more or less on all railways hitherto constructed;" stating that their object was to obtain, with reference to the great momentum of the masses to be moved by locomotive steam engines on the railway,

"1st. The strongest and most economical form of rail;

"2nd. The best construction of chair;

"3rd. The best mode of connecting the rail and chair, and also the latter to the stone blocks or wooden sleepers; and that the railway bars were not to weigh less than fifty pounds per single lineal yard."

In consequence of this advertisement, a number of plans, models, and descriptions were deposited with the Company within the time limited by the advertisement, and others were received afterwards, which although not entitled to the prize, were still eligible to be considered with reference to their adoption for trial. On the 24th of December, 1834, a resolution was passed at a meeting of the Directors, appointing J. U. Rastrick, Esq., of Birmingham, N. Wood, Esq., of Newcastle, Civil Engineers, and P. Barlow, Esq., of the Royal Military Academy, Woolwich, to examine and report upon the same. These gentlemen met in London, and after a long and careful examination of the several plans, drawings, and written descriptions, recommended those which they thought were entitled to the prize, which was awarded by the Directors accordingly. But that part of their instructions which required them to recommend one or more rails for trial, they were unable to fulfil to their satisfaction, principally for want of data to determine which of the proposed rails would be the strongest and stiffest under the passing load, and whether permanently fixing the rail to the chair, for which there were several plans, would be safe in practice; and as no experiments on malleable iron had ever been made bearing on these points, it was considered better to leave the question unanswered, than to recommend on no better ground than mere opinion an expensive trial, which might ultimately prove a failure.

A great variety of contrivances have been set forth for fixing the permanent lines of rails, either by means of chairs fixed to stone blocks, or transverse wooden sleepers, or by giving the rail a continued bearing on longitudinal timbers, as adopted on the Croydon Railway, hereafter to be described, and represented in Plate LXXII., and as will be adopted on the Great Western Railway, for fixing the rails which are represented in cross section in Plate LXXVI. It does not, however, yet appear, that the most perfect form of fixing the rail to the chair has been suggested, each method at all worthy of trial either has been or is now under the process of experiment. Among others which appear worthy of confidence, is the chair for parallel double **T** rails, proposed by G. W. Buck, Esq., Resident Engineer on part of the London and Birmingham Railway. This chair is represented at Plate L., and we shall here insert Mr. Buck's own description thereof, which he has kindly forwarded to us for that purpose.

"In the first place, it is necessary to observe, that however strong the rail may be, a certain amount of deflection between the points of support must result from the gravity of the passing load; therefore, in order that no motion may be communicated to the chair (which is essential to the maintenance of the road in good order), the connexion between the rail and chair must be such as to allow of the libratory motion arising from deflection, the rail being, nevertheless, firmly fixed upon its seat, incapable of rising therefrom, and prevented from lateral movement; at the same time it should be free to move longitudinally as much as the expansion and contraction of its length from variation of temperature may demand. All these ends are attained by having the chairs constructed as shown in Plate L., to which I will now refer.

"The Engraving contains a plan and elevation of a 'joint, or double chair,' and of an 'intermediate, or single chair.'

"It will be perceived that the elevations of both are identical. The same letters refer to the same parts in all the figures. In the elevation of the chairs, the rails are sectionally represented in their places; in the plans they are omitted. The seat of the rail in the chair at D is convex, being three-sixteenths of an inch higher than at E E; this form permits the libratory motion of the rail on its seat at or near D, but is not peculiar to the chair I am now describing; it has been adopted in others, and is sometimes called '*cat-backed*.'

"That side of the chair which is next to the flanges of the wheels has contact with the rail at only two points, A and B; these are blunt points, produced by the side of the chair being formed into spheroidal knobs; A is in contact with the vertical rib of the rail, and B with the superior part of the lower web, where a tangent to its curved surface forms an angle of 45 with the vertical. On the outer side of the chair the rail is confined to its place by a cast-iron '*chock*,' or *filling-in piece*, F; that part of it next the rail is also made in a spheroidal form, and touches in a point only at C, about midway between A and B.

"This chock has a step or foot, G, resting on the seat of the chair, with a fillet, I, fitted into a corresponding groove in the chair, and the chock is wedged against the rail by means of the wrought-iron key, H; this key is passed into a mortice, one-half of which is in the chock, and the other half in the chair, by which the key and chock are secured in their relative positions.

"The mode of laying the rails in these chairs is as follows:—The blocks or sleepers, with the chairs affixed thereto, being previously laid in their places, the rails are dropped into the chairs (the width between A and K being sufficient for that purpose), and the chocks are then inserted horizontally, and wedged up by means of the keys, H.

"The effect produced by keying the chocks moderately tight against the rail at C, is to force the rail against the points A and B, and thereby, at the same time, down upon its seat at D, by the action of the point B on the inclined surface of the rail in contact therewith. Now, it must be obvious, that so long as the key remains in its place, the rail is completely fixed laterally and vertically, and that it will be easily moved longitudinally when contracted or expanded by difference of temperature; also, that the libration of the rail, occasioned by deflection, will produce only a very minute rubbing at the points A, B, and C.

"A notch is made on the outer side of the head of each key for the purpose of extracting it by the application of a lever or pinch bar.

"The joint or *double* chair differs from the intermediate or *single* chair only in being so much wider as to receive a double chock, with two knobs on it, each of which is keyed against the side of the end of one of the two rails which meet in the chair, the chock having two keys for that purpose. Here I wish to observe, that the only doubt which I have hitherto heard entertained, as to the complete success of this chair, is the chance of the keys getting loose, and jumping out of their mortices when a train may be passing at a high velocity; the most satisfactory answer to which is, that upon the London and Birmingham Railway, about four hundred yards in length have been laid by way of experiment with these chairs, over which the passenger trains have been running at velocities generally exceeding thirty miles an hour, without the least appearance of the keys working out; but, on the contrary, most of them have rusted fast into their places, and the points of contact have become smooth, and a little brightened by the libratory motion, which is an indication that these chairs fully answer the purpose intended.

"In a rail weighing sixty-five pounds per yard, with four feet bearings, the space moved through at each deflection by that part of the rail which is in contact with the point C, is $\frac{3}{1000}$ of an inch.

"These chairs are designed as a substitute for those now very generally adopted for similar rails, in which wood keys, or filling-in pieces, from five to nine inches long, are used, and to which there are the following objections:—

"1st. The keys, or filling-in pieces of wood, are liable to shrink in dry weather, and consequently to become loose and get out of their places.

"2nd. Instead of keeping the rails down upon the seat, they lift them from it, and a blow is produced by the passing load forcing the rail down upon the seat of the chair.

"3rd. In the joint chairs, one end of the key or filling-in piece is pressed down by the deflection of the rail, and at the same time the other end of it is elevated, whereby the but-end of the contiguous rail, to which the wheel is advancing, is raised above the level of that upon which the wheel is at the instant pressing, and a shock is produced by the wheel coming into contact with the but-end thus raised. This effect is produced when there is sufficient room in the chair for the play of the rail; but when the rail tightly fits the chair, a rocking motion is communicated to the chair, and by the chair to the block, or sleeper, by which the road is rapidly put out of order.

"4th. I think it must be admitted, that the wood filling-in pieces will prove less durable than the cast-iron chocks, even supposing the wood to be Kyanized."

SPECIFICATION

Of Rails, Chairs, Wedging-bolts, Keys and Pins for the London and Birmingham Railway.

Rails.—To be of malleable iron, from No. 2 Mine, entirely free from cinder, the rails being No. 3 when finished. Length of rail sixteen feet, parallel form, square ends; bearings four feet apart from centre to centre; depth four inches and three-quarters; width over the top two inches and a half; sixty-five pounds per yard.

The precise form and dimensions of the rail in section will be understood on reference to the accompanying full-sized Drawing, Fig. 1, which represents the general section of the rail between any two bearings. At each section the form of the bearing is changed by the vertical rib being thickened so as to become equal in breadth to the bottom web, making the section at these points a simple T shaped rail, as shown by the dotted lines, Fig. 1.

In cutting the ends of the rails, whatever method may be adopted, they shall, when finished, present a uniform sectional outline, accurately corresponding with the section of the adjoining portion of rail, and exactly square with the top surface of the same.

At the works where the rails may be manufactured, five chairs, of the description and dimensions hereinafter specified, shall be firmly fixed by spikes, at the proper distances, on a balk of timber. Into these chairs every rail as it is completed shall be inserted, for the purpose of ascertaining that the positions of the thickened portions, forming the bearings, are properly situated, and correctly fit the recess in each chair, and that the length does not exceed or fall short of sixteen feet, as no deviation will be allowed.

In addition to accurately fitting the chairs, the rails must be entirely free from any warping, and present a uniform unbroken surface in every part, as all rails will be rejected which exhibit any symptoms of imperfect welding, whether appearing on their sides or upper surfaces.

Chairs.—To be made from No. 1 strong grey cast-iron, and of two kinds—double, or joint chair, and single, or intermediate chair.

Double, or Joint Chair—Will be accompanied by two wrought-iron pins, two wrought-iron wedging-bolts, and two wrought-iron keys. The chair to be cleanly cast, free from air-holes, sound, and correctly moulded. The recess in the chair for the reception of the rail shall not exceed the sectional dimensions of the rail more than will admit the rail to drop tightly into it. The greatest attention will be required to this fitting.

Single, or Intermediate Chair.—Will be accompanied by two wrought-iron pins, one wrought-iron wedging-bolt, and one wrought-iron key. The same care will be required in casting this chair and fitting it to the rail as specified for the double chair.

Wedging-Bolts.—The form and dimensions of the wedging-bolts, as well of the keys, will be understood by reference to the Drawings. To be of the best malleable iron, the key-hole to be truly punched in the axis of the bolt, and the bolt to be swaged and made truly cylindrical throughout, so as to fit the hole in the chair accurately, without any play. Should the hole in the chair be rough, or otherwise untrue, it shall be carefully rimered out until the bolt fits it in the manner described. Especial care will be required to punch the hole clean and true, and in its proper position, so that before the key is driven about half home, the chisel end of the bolt shall bear firmly in the groove of the rail. All these bolts to be thoroughly case-hardened.

Keys.—To be of malleable iron of the best quality, well hammered, split at one end, as shown in the Drawing, Fig. 6, and carefully squared at the other. Each key to be uniformly tapered, so as to effect one quarter inch of draw. The thickness of the key to be uniform throughout, the tapering sides to be straight and cleanly forged.

Pins or Spikes.—Pins or iron spikes for fixing the chair into the block to be seven inches long, and three-fourths of an inch in diameter, with a head not less than one inch and a quarter in diameter, and five-eighths of an inch in thickness.

N.B.—The Directors, being anxious that the most scrupulous care should be taken to form the rails, and all the other wrought-iron parts above described, of the best No. 2 Mine-iron only, will reserve to themselves the power of sending one or more inspectors, either occasionally or permanently, to the works where the iron and rails are manufactured, the parties whose tender may be accepted binding themselves, at all times during the progress of the execution of the above rails, chairs, &c., to afford every facility of access to such inspectors to all parts of the works which they may deem necessary for satisfying themselves that the manufacture of the iron or rails is in every respect in accordance with the above Stipulations.

With the view of removing as much as possible all ambiguity as to the mode of manufacture, the

following particulars are considered as implied by this Specification :—The iron to be refined. The puddled ball to be put under the shingling hammer and rolled into rough bars, by some called "puddled bars," by others, "No. 1." These bars being cut into convenient lengths, are to be ball-furnaced, hammered, and rolled into Merchant or No. 2 bars; these bars again cut, heated as before, and rolled into rails. Parties tendering, who do not propose to follow the above method strictly, are requested to state in similar detail the process to which their Tender applies. Further particulars and explanations may be had by personal application to the Engineer, at the Railway Office, St. John's Wood, London.

The whole of the rails, &c., specified above are to be delivered on board a canal barge in the Pool, or on the Company's Depot, Camden Town, on the Regent's Canal, London.

SIDING OR PASSING PLACE.

Plate LI.

In this Plate is given the details of the sidings or passing places, the crossing from one line of rails to another, and the points or switches by which a change of line or communication is effected. The manner of producing the change is by that ingenious and extensively useful contrivance, an eccentric motion, which is enclosed in a box; the manner of its action we consider too obvious to require a lengthened detailed description. The Specification for their preparation is given at page 27.

SPECIFICATION OF TURN-RAILS.

Plate LII.

The turn-rails to be twelve feet diameter, and all cast-iron, except where otherwise described.

The table to be hung to and turn upon a centre pivot A, and eight cast-iron rollers, B B, working upon wrought-iron arms, C C, radiating from a wrought-iron hoop, D, working round the centre pivot. The whole table is to be enclosed by a cast-iron ring, E E, twelve feet seven inches diameter outside, and one foot six inches and a half deep; upon this ring the circular rail, F F, is to be cast, for the rollers to work upon. The centre diameter of this rail to be eleven feet three inches, and its width one inch and a half. The outside ring is to be cast in two parts, and bolted together by means of flanches and three screw-bolts, one inch in diameter each, on each side, as shown in the Drawings at G G. The section of this ring is shown in the Drawings, with the respective thicknesses marked on.

The top or table consists of four principal arms, marked I I, traversing the tables at right angles, nine inches deep at their centres, and six inches and three-quarters at ends; also four arms radiating from the centre-piece to the corners formed by the others; these arms, marked K K in the Drawings, are eight inches and a quarter deep at the centre-piece. Holes, three-quarters of an inch in diameter, are to be cast in the first-named arms for fastening the railway bars or rails to the table. At the extremity of these arms is the circular rail, M M, for working or bearing upon the rollers, its centre diameter to be ten feet three inches and a half, and its width two inches. The section of this, with the respective thicknesses marked on, is shown in the Drawings. In the centre-piece four holes are to be cast for receiving one inch and a quarter screw-bolts for hanging the table to the centre pivot. The spaces between the principal arms are to be left open, and grating, of the shape shown in the Drawings, to be put on afterwards.

The table to work upon eight cast-iron rollers, B B, of the shape shown in the Drawings, and ten inches diameter; to have a hole in their centres (bored out) for a three-quarter rod to work freely in; the periphery of each roller to be turned. These rollers to work between two wrought-iron hoops, P P, five-eighths thick and two inches deep (and made in two parts), and on eight wrought-iron arms, C C, three-quarters of an inch in diameter each, which arms are screwed into the hoops, and a nut is then to be screwed up tight against each hoop, as shown in Drawings by the letters Q Q. The other extremity of these arms are to be screwed into

another wrought-iron hoop, D D, two inches deep and one inch thick; the inside diameter of this hoop to be five inches, and to be turned so as to work round the collar on the centre pedestal, R.

This centre pedestal to be cast-iron, with a hole three inches diameter and five inches deep in its centre (to be bored out); into the bottom of this hole a brass step, S, is to be put, two inches thick, for the pivot to work upon. The collar for the hoop, D, to work upon must be turned. Four holes, one inch diameter, to be cast in the feet of the pedestal for fastening it to a strong iron cross.* The centre pivot, A, to be cast-iron, thirteen inches long, including the head, which is to be one inch thick and ten inches diameter, with four holes, fourteen inches diameter each. That part of the pivot working in the pedestal to be three inches diameter, with a rounded end, as shown in the Drawings. The working part of the pivot to be turned. The remaining part of the pivot, to the underside of the head, to be four inches diameter; a hole, V, to be cast down the pivot in a slanting direction for the supply of oil to its working parts, so that it shall run into the pedestal at the side of the pivot. The table is to be hung to this pivot by four screw-bolts, one inch and a quarter diameter each, in such a manner that the table may be eased off or lowered on to the rollers at pleasure. The heads of these bolts to be countersunk into the centre-piece, as shown in the Drawings. On the surface of the table there must be fixed two lines of Railway, at right angles to each other, the distance between the rails to be four feet eight inches and a half inside. The bars or rails, W W, to be wrought-iron, three inches broad and two inches thick, and of the shape shown in the Drawings, bolted to the principal arms with three-quarters of an inch screw-bolts, the heads being countersunk into the rails. Four sets of wrought-iron inclined planes to be fixed at the intersection of the rails, for the flanches of the wheels to run upon when passing the openings. A latch, X, to be fixed to the table, and two catches, Y Y, to be cast on the outside rim, at right angles to each other, for holding the table in the required positions.

The whole of the materials and workmanship to be of the best possible description, and the Contractor to uphold all the parts for six months, replacing any unsound castings or imperfect workmanship. The Company's Engineer, or any person whom he may appoint, may reject any turn-rail, or part of one, which he may think is not sufficiently sound.

N.B.—The top, or table, may be cast in two parts.

SPECIFICATION

FOR A FIRST CLASS COACH FOR THE LONDON AND BIRMINGHAM RAILWAY.

Plate LIII.

THE BODIES.

Each coach is to consist of three bodies, or compartments, as represented in the annexed Drawing, Fig. 1, the extreme length, outside measure, being fifteen feet six inches; the length of each body four feet eleven inches, the breadth six feet, and the height from floor to roof, four feet six inches and a half, all inside measure, and exclusive of the stuffing. The frame-work of the bodies must be made of well-seasoned ash of the following dimensions: for the bottom sides, two inches and a half by four inches and a half; standing pillars at the corners and doorways (twenty in the three bodies), two inches and a half, with a sweep three inches at the widest part, and the turn-under two inches and a half, the standing pillars in the doorways being strengthened at the bottom by uprights of birch, firmly screwed to the seat rail; the top rails two inches and a half by one inch and a half; the cross-bars for the two ends (four in each), two inches and a quarter by two inches, with battens of ash between, two inches and a half by one inch and a half, and not less than twelve of them at each end; the cross-bars across the divisions (one for each), two and a half by one inch; the seat rails (ten in the three bodies), one inch and a half by two inches and a half; the hoop

* In the early constructions of this kind, a large stone block was employed to fix the centre, instead of the cross represented in the Engraving.

sticks to support the roof (four in the two end bodies, and three in the middle body), two inches and a quarter wide, by one inch and five-eighths thick; the sides to be battened with ash of the same strength, and in the same manner, as the end of the coach; the flooring of American pine one inch and a quarter, plated underneath with three strap plates of wrought-iron, one inch and a half wide by a quarter of an inch thick from end to end, secured by about one hundred clip-headed bolts and nuts; the divisions between the bodies of the same three-quarters of an inch thick; seat-boards of the same also three-quarters of an inch; the roof of the same also to be three-quarters of an inch; to be covered with three hides weighing not less than thirty-eight pounds each, protected on the top with ribs of ash screwed on three inches apart, two inches and a quarter broad, by five-eighths of an inch thick. The roof to be bound with a beading of ash one inch and a half square, screwed on and projecting so as to allow of the rain to drop clear of the pannels; to be channelled and to stand somewhat higher over the doors; seats, E, at both ends of the roof, to hold two persons on each, with iron seat rails, F, three steps, G, on each side, and two iron handles covered with leather at each end, to mount; and a foot-board of birch, H, supported underneath with iron stays. The roof, for the space of eight feet six inches, to be fenced along and across with luggage rails, D, five-eighths of an inch in diameter, of iron, supported at intervals with uprights four inches and a half high, and an oiled canvass luggage sheet, with straps complete, of dimensions sufficient to extend over the same. The whole of the exterior of the coach to be panelled with well-seasoned panel board, the upper quarters, B, half an inch thick, lower quarters, A, five-sixteenths of an inch thick, and ends half inch, C, Fig. 3; the panels before being fixed, to be covered with canvass glued on, and when fixed, which must be done with copper sprigs, one inch apart, they must have glued on them a second lining of canvass. The mouldings to be of brass, and blacked if required. Brass door and side handles; two lamp irons to each coach, and two large sized lamps upon an approved principle. The windows (two in each body) to be of good plate glass, twenty-two inches and a half by nineteen inches, and not less than five-sixteenths of an inch thick; and the frames to be made of well-seasoned oak one inch and a half broad, and to be covered with strong black velvet, or painted, filled up, pumiced, and varnished as may be required; small leather pads, stuffed with horse hair, to be put at the bottom of the glass stop, for the glass to fall upon when let down. The painting to consist of three coats of white lead or colour, and four coats of filling-up; after being well pumiced, the body to receive three more coats of the same colour, and is then to be finished with two coats of a colour to be approved by the Directors; the upper quarters are to be painted black in like manner, and the whole body is to be varnished with four coats of the best varnish. The panels are to be lettered in gold, and ornamented in the centre with a coat of arms or other device. The insides to be lined throughout with drab cloth, of a quality worth at the present time twelve shillings and sixpence per yard, of sixty inches wide, the quantity required for the three bodies being about thirty-eight yards. Lace (seven dozen for the three bodies) eighteen shillings per dozen. Seaming ditto (twelve dozen) three shillings and sixpence per dozen. Pasting ditto (four dozen) three shillings and sixpence per dozen. Holders of lace, and glass strings of the same, lined with strong leather hat strings; and the floor to be covered with the best Brussels carpet. The backs and cushions to be stuffed with the best curled hair, the quantity required for the three bodies being about one hundred and twelve pounds. The seats to be divided with four arms in each body, fixed on with iron corner plates and screws, and finished with broad mahogany tops, varnished; each seat also to be numbered with a japan label with gilt figures. The bodies to be firmly fixed upon the under carriage, with strong bolts secured with nuts; the whole of the workmanship to be strong and substantial, equal in every respect in style and execution to that of the coaches the most recently built by the Liverpool and Manchester Railway Company, at their yard in Crown Street, Liverpool. The whole of the iron-work to be of the best quality, the weight of that portion attached to the bodies, consisting of luggage rails, steps, bolts, foot-board, stays, &c., being about one hundred weight one quarter and twenty-four pounds. Screws to be used throughout instead of nails.

UNDER CARRIAGE FRAME.

The plan of the under carriage frame will be seen by the annexed Drawing, Fig. 2; --its extreme length is fifteen feet eight inches, the buffers extending one foot nine inches beyond at each end. The whole must be made of well-seasoned ash of the following parts and dimensions:—The carriage sides, Fig. 1, I (two on each side, but they may be made in two pieces, spliced in the middle and fitted with iron bolts and nuts), must be three inches square, coupled together vertically by wrought-iron props, Fig. 1, K, and corner plates,

eight of the former in each carriage weighing two quarters twenty-five pounds, and four of the latter weighing two quarters eighteen pounds. The ends of the carriage, Fig. 3, consist of two pieces of ash, L, at each end, extending from side to side (six feet one inch), three inches and a half wide by three inches thick, and swelling to eleven inches and a half at the deepest part, morticed together as in the sides, only with three upright blocks, M, of ash instead of iron. The frame is strengthened by four diagonal, Fig. 2, N, two centre longitudinal, O, and two centre cross-stays of ash, each three inches by two inches and a half, extending from the lower carriage side morticed into a solid piece of ash, Q, in the middle of the frame, two feet three inches by one foot four inches, and three inches thick, secured thereto as well as to the carriage sides by strong angle plates of wrought-iron, and plated at the corners with wrought-iron three-eighths of an inch thick, two inches and a quarter wide, fixed on with half-inch bolts and nuts, The two centre longitudinal stays, the two centre cross-stays, and the whole of the lower carriage side, Fig. 1, F, must be plated throughout on one side with wrought-iron three-eighths of an inch thick, two inches and three-quarters wide, and fixed in the same manner as the corner plates, with bolts and nuts. The weight of the plating will be about two hundred weight and twenty pounds, and that of the bolts and nuts (about 350 of each) one hundred weight two quarters. There must be four axle guards, Fig. 1, R, of wrought-iron, tapering from three-quarters of an inch to five-eighths of an inch thick, firmly fixed to the carriage sides by bolts and nuts in *exact* square with each other, at the distance of eight feet six inches from centre to centre. The steps, S, consisting of eighteen, and weighing about one hundred two quarters and twenty-two pounds, having a tread of twelve inches by nine inches, must be fitted in like manner to the carriage sides. There must be eight wrought-iron roller boxes weighing, with rollers for the same, three quarters of a hundred weight; these are to be screwed upon the under part of the carriage sides, for the extremities of the sides or bearing springs to rest and work upon.

BUFFERS AND DRAWING APPARATUS.

There are in each carriage four large buffer rods, Fig. 1, T, of wrought-iron, weighing two hundred weight one quarter and six pounds, with a but-end of ash, U, fourteen inches diameter, covered with stout leather, and stuffed with horse hair; these rods abut upon two large springs, Fig. 2, V, having fifteen plates, each of quarter-inch steel, three inches broad, and, when fixed, five feet nine inches long; there are also two drawing springs, W, with six plates, each of steel, of the same dimensions, and three feet long, the weight of the four springs being three hundred weight and twenty-five pounds. These are fitted into a groove, X, which is firmly bolted upon the slab of ash in the centre of the frame, with liberty to work to and fro for the space of two inches and a half. The iron-work connected with the buffer and drawing apparatus (besides the buffer rods already mentioned), consists of draw rods and plates, Y, attached, weighing three quarters and twenty-two pounds; four square socket rings and buffer plates, Z, weighing two quarters and eighteen pounds; one groove plate, *a*, two side plates, and two edge plates, weighing two quarters and six pounds. The weight of sundry small iron-work about the under frame, not enumerated, may be estimated at three quarters of a hundred weight.

The whole of the steel for the buffer and draw springs, as well as for the bearing springs hereafter described, to be well tempered, and of the best quality, and all the iron to be also of the best quality, well and neatly wrought, filed, and fitted; the framing to be firm and substantial, and to be constructed according to the most approved mode adopted in the recently built carriages on the Liverpool and Manchester Railway. The carriage to be painted with five coats of paint, of the colour corresponding with that of the bodies, to be neatly picked out, and finished with two coats of the best varnish. There must be three chains at each end of the carriage about eighteen inches long, with an open link with a bolt and nut at one end, and a strong hook at the other—the centre chain being the one by which the carriage is drawn, must be rather stronger than the other two, which are only for additional safety. The weight of the six chains may be about one hundred weight two quarters.

BREAK.

As it is not necessary that every carriage should be provided with a break, this must be considered an extra, and a separate Tender made for it accordingly. It consists of a number of levers, tooth and pinion

wheels, &c., the application of which can only be understood by inspection or detailed drawings. It acts on both sides of the two wheels on the same side of the carriage simultaneously. The whole of the apparatus will be about four hundred weight.

WHEELS, AXLES, AXLE BOXES AND SPRINGS.

The wheels must be made with the rim and spokes of wrought-iron, and the nave of cast-iron, of a plan and construction to be approved of by the Engineer. The outer rim or tire to be tapped on the inner rim with not less than eight screw-bolts and nuts in each wheel. The axle to be made of the best rolled or wrought-iron, three inches diameter in the centre, and three inches and a half where it passes through the nave, to be turned down to two inches and five-eighths, for an outside bearing of four inches and a half long, which must be case hardened. The wheels to be firmly keyed on the axle with a five-eighths of an inch key, according to a gauge, and the tire to be turned to a template to be furnished by the Engineer, and to be painted and picked out with one coat of paint, and a coat of varnish. The weight of the four wheels and two axles is about eighteen hundred weight. The axle boxes, Fig. 1, *b*, which are of cast-iron, must be fitted up with brass steps to suit the journals, and to be of the best quality. Upon the axle boxes are fixed the side or bearing springs, Fig. 1, *c*, of which there are four, having each twelve plates quarter-inch steel, three inches wide, and when weighted are five feet long: the weight of the four is about three hundred weight one quarter and fourteen pounds.

RECAPITULATION OF THE IRON WORK.

	cwt.	qrs.	lbs.
Luggage rails, lamp irons, and other body work ..	2	1	4
Eight iron props between upper and lower carriage side	0	2	[illegible]
Four corner plates at each corner of under carriage... .	0	[illegible]	18
The plating under the carriage sides and centre	2	0	26
About 350 bolts and 350 nuts..	1	2	[illegible]
Four large buffer rods	2	1	[illegible]
Two buffer springs, and two draw springs	3	0	25
Draw rods and plates attached	0	3	22
Four square socket rings and buffer plates	0	2	18
One groove plate, two side ditto, two edge ditto	0	2	6
Four axle guards	1	1	19
Six draw and safety chains	1	2	0
Four side or bearing springs	3	1	14
Eight roller boxes and rollers..	0	2	13
Eighteen steps	1	2	22
Sundry iron work about the under frame, not enumerated .	0	3	0
Axle boxes and brasses	1	2	0
Wheels and axles	18	0	0
Break apparatus	4	0	0
Total weight of iron work in each carriage	47	3	16

A model of the proposed carriage may be inspected at the office of the London and Birmingham Railway Company, No. 83, Cornhill, London, and a full-sized pattern coach may be seen, and all other particulars had, on application to Mr. Woods, at the Company's Office, India Buildings, Liverpool. The weight of the iron work, and the dimensions of the wood-work, are furnished in the foregoing Specification, in order to facilitate the calculations of coachmakers, and others who may be disposed to contract with the Company; but it is clearly to be understood, that in all matters relating to the mode of construction, the fitting, finish, arrangement, or design, reference is to be had wholly and entirely to the full-sized pattern coach, which will be exhibited in Liverpool, and not to the model in London, or to the above description, or the accompanying drawing; and it must be further understood, that the Contract is to be completed to the satisfaction of the Engineer of the Company, or of any other person appointed by the Directors to inspect and pass the work.

The carriages must be delivered at the Company's Station, at Euston Grove, London, or at their Station in Birmingham, at the option of the Directors, not later than day of 1837.

GREAT WESTERN RAILWAY.

PLATES LIV. TO LVIII.

THE Act of Parliament granting powers for the construction of this Railway, entitled " An Act for making a Railway from *Bristol* to join the *London* and *Birmingham* Railway, near *London*, to be called 'The Great Western Railway,' with Branches therefrom to the Towns of *Bradford* and *Trowbridge*, in the County of Wilts," was passed 31st August, 1835, after a long and protracted opposition. The estimated cost of this undertaking, and the sum which the Company were empowered by this act to raise, was two millions five hundred thousand pounds, the whole to be divided into shares of one hundred pounds each; and if such sum should be found to be insufficient for the purposes of the Act, the Company were empowered to borrow and take up at interest any further or additional sum not exceeding in the whole the sum of eight hundred and thirty-three thousand three hundred and thirty-three pounds, on the credit of the said undertaking. A second Act of Parliament, entitled " An Act to alter the line of the Great Western Railway, and to amend the Act relating thereto," was passed 19th May, 1836. By this Act power was obtained to alter the line of Railway in certain cases, in the counties of Gloucester, Wilts, Berks, Bucks, and Middlesex, and the city and county of the city of Bristol. And to amend and enlarge some of the powers of the former Act, two additional Acts of Parliament passed 3rd July, 1837, one entitled " An Act to alter the Line of the Great Western Railway, and to amend the Acts relating thereto;" the other entitled " An Act to enable the Great Western Railway Company to extend the Line of such Railway, and for other Purposes relating thereto." By the former of these Acts power was obtained to alter the line in certain cases, in the counties of Berks, Oxford, Wilts, and Somerset, and to take additional lands for the purposes of depots and approaches to the said Railway, and also to amend and enlarge some of the provisions in the former Acts. By the last-named Act, the Company obtained power to extend the Railway to a space of ground adjoining the basin of the Paddington Canal, in the parish of Paddington, at the western extremity of the metropolis.

This grand undertaking was first proposed in the year 1832, when the greater portion of the mercantile interest of Bristol, consisting of the Municipal Corporation of that city, the Society of Merchants, the Bristol Dock Company, the Chamber of Commerce, and the Gloucestershire Railway Company, appointed a Provisional Committee to take the necessary steps for the formation of the Company. A correspondence was opened with the principal commercial establishments of South Wales and Ireland, who traded either with Bristol or London, with a view to obtain their sentiments upon the advantages to be derived to commerce by the construction of the Railway; so favourable was the general opinion, that ninety out of one hundred of the most respectable firms approved of the measure. At this stage of the business, the requisite funds to defray the expenses of the preliminary surveys were subscribed by the above-named bodies, and J. K. Brunel, Esq., was appointed Engineer to the Company. The first application to Parliament, in 1834, was unsuccessful, and it was not till the 31st of August, 1835, as above stated, that the Royal Assent was given to the Act of Incorporation. The preliminary or parliamentary expenses in obtaining this Act, including those of the preceding year, owing to the protracted opposition, amounted to the enormous sum of eighty-eight thousand seven hundred and ten pounds ten shillings and eleven-pence.

The operations for the construction of this Railway are now proceeding with an almost unprecedented vigour, under the direction of the highly-talented and scientific Engineer above named, who has permitted the working drawings of two of the principal objects of interest on the line to be copied for this work. These are given in Plates LIV. to LVIII., and contain the elevations, plans, and sections, both longitudinal and transverse, of the Viaduct over the valley of the Brent, and of the Bridge over the Thames at Maidenhead. The latter structure is now in the course of erection; the former is completed, and of which we are able to give the following particulars :—

THE WHARNCLIFFE VIADUCT.

The Engravings, Plates LIV. to LVI., represent the Plan, Elevation, and Sections of the Wharncliffe Viaduct, one of the principal works on the Great Western Railway.

The River Brent, across the valley of which this Viaduct is constructed, receives the drainage of a district of which Harrow, Elstree, Barnet, and Highgate form the exterior boundary, and the streams from which points, uniting in the neighbourhood of Wilsdon, pass down a single channel by Twyford and Hanwell to fall into the Thames at Brentford. This valley is crossed by the London and Birmingham Railway at Twyford, and by the Great Western Railway at Hanwell, six miles lower down.

The execution of the Wharncliffe Viaduct formed the Contract No. 1, London Division; the first Contract let along the line, and about the first completed. This Contract was obtained by Messrs. Grissel and Peto.

The arches are elliptical. The piers consist each of two massive square pillars, rising from a single plinth, and surmounted by simple capitals of stone of a somewhat Egyptian character.

The wing walls are straight, and the space between them, which is hollow, is covered by a transverse arch, springing from wall to wall, the walls being inclined in the direction of the thrust resulting from the arch.

The particulars of the work are as follows:—

		Feet	Inches
Total length, including wing walls		900	0
Eight main arches	Span of each	70	0
	Rise	17	6
Breadth between the parapets		30	0

The foundations of the piers were carried through the loose gravel about three feet into the strong blue clay, and the foot of each pier stands on an area of two hundred and fifty-two square feet.

By the month of August, 1836, about eleven thousand cube yards of brickwork had been executed, and about ten thousand cube feet of stone was in place. The abutments were forward, and the piers had reached the height of the stone caps; and by February, 1837, the arches were all turned.

Upon striking the centering the arches followed from one inch and three quarters to two inches and three quarters, the latter being the greatest fall, and the average being below two inches. The spaces between the arches were crossed by spandrell walls, and a floor of York landings laid upon the whole; the parapet and coping were added at a later period. The work was commenced in February, 1836, and was completed at the latter part of the summer of the following year.

The Brent is carried through a brick channel, beneath the second arch.

The Viaduct is met at each end by an embankment; that on the east is formed from the excavation for the Railway towards Acton, consisting principally of gravel, and that on the west is formed entirely of a very hard binding gravel, obtained from side cuttings at the top of the hill.

The Wharncliffe Viaduct was so named in acknowledgment of the services rendered by Lord Wharncliffe to the Company, as their Chairman in the Lords' Committee, and the principal supporter of their Bill in the Upper House.

MAIDENHEAD BRIDGE.

This bold and magnificent undertaking is represented in Plan and Elevation in Plate LVII., and in Section, both longitudinal and transverse, at Plate LVIII. It consists of two arches, each of one hundred and twenty-eight feet span, with an intermediate pier of thirty feet in width. The Plates are exact reduced copies of the working Drawings, and contain all the necessary dimensions for re-producing those Drawings to any enlarged scale. The materials of which this structure is composed is almost entirely of brick, with a

very small proportion of stone. These arches will be the first of such a magnitude turned wholly in brick. The result, which will now very soon appear, will, doubtless, confirm the high reputation for science and enterprise enjoyed by the eminent Engineer who designed, and is now executing, the work.

LONDON AND SOUTHAMPTON RAILWAY.

PLATES LIX. TO LXIV.

THE Act of Incorporation of this Company, entitled "An Act for making a Railway from London to Southampton," received the Royal Assent on the 25th of July, 1834. The capital they were empowered to raise, "for making and maintaining the said Railway and other works, by this Act authorized, and for the general purposes of this Act," was the sum of one million pounds sterling, to be divided into twenty thousand shares of fifty pounds each. And in case the money so authorized to be raised by subscription should be found insufficient for the purposes of the Act, the Company were empowered "from time to time, to borrow and take up at interest any further or additional sum of money, not exceeding the sum of three hundred and thirty thousand pounds, on the credit of the said undertaking." A second Act of Parliament was obtained by the Company, 30th of June, 1837, entitled "An Act to alter the Line of the London and Southampton Railway, and to amend the Act relating thereto." By this Act power was obtained to alter the line in five different portions; to divert the Rivers Wey and Mole, &c., and also certain turnpike-roads; to purchase forty acres of land, in addition to what they were before empowered to do, for the construction of stations, &c.; to raise by subscription an additional sum of four hundred thousand pounds, to be divided into sixteen thousand shares of twenty-five pounds each; also to enable the Company to raise by mortgage the sum of four hundred and sixty thousand pounds, instead of the three hundred and thirty thousand pounds authorized by the former Act; and, lastly, to extend the time for the completion of the said Railway an additional three years.

This line of Railway begins on the south bank of the River Thames, at a place called Nine Elms, in the parish of Battersea, a short distance above Vauxhall Bridge, and terminates at the beach of the Southampton water. The works on the line are now proceeding rapidly, and it is expected that a considerable portion of it will be opened to the public by the beginning of May next (1838). The last Report of the Directors of the Company, dated August, 1837, contains the following observations:—"It is highly worthy of remark, that the circumstance of this Railway having one of its Termini at the water's edge in Southampton Harbour, and the other at a wharf on the bank of the Thames, affords every convenience which nature and art combined can give for such a traffic. With respect to the situation of the London Terminus, as it bears upon the convenience of passengers, the following statement of the distances from the Royal Exchange, and from Charing Cross, of the Termini of the London and Birmingham, the Great Western, and the Southampton Railways, will show the local merits of each:—

DISTANCE FROM	TO CHARING CROSS		TO THE ROYAL EXCHANGE	
	Miles	[illegible]	Miles	[illegible]
The Terminus of the London and Birmingham Railway at Euston Square	1	65	3	16
The Terminus of the Great Western Railway at Paddington	2	60	4	26
The Terminus of the London and Southampton Railway at Vauxhall	1	77	3	9

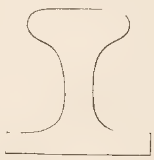
"In addition to the usual accommodation by omnibuses, arrangements are being made by which the passengers will be conveyed in small steam-boats, and landed at any point between Vauxhall and London Bridge, within a few minutes of the time of their arrival at the Station. These small steam-boats will be in

waiting at the Terminus Wharf for the arrival of the different trains, and in like manner they will start from the different points of embarkation along the River, in time to reach the Station before the departure of the trains."

Plates LIX. to LXIV. contain reduced copies of the working Drawing of some of the road bridges, both in cutting and embankment, on this line of Railway, which will be applicable in like situations upon any other line of Railway. Plate LXIV. contains the Plan, &c., both of an earth and timber-waggon; the former is similar to those used in the formation of the embankments and cuttings in and near Battersea Fields, and cost from sixteen to seventeen pounds. The timber-carriage is the same as was contrived by Mr. John Dixon, when Resident Engineer on the Stockton and Darlington Railway, and is similar to those afterwards used on the Liverpool and Manchester Railway. Springs have subsequently been applied to this kind of carriage, which is necessary on account of the greater speed introduced upon Railways since the opening of the Stockton and Darlington Line. The permanent road will be laid on wood sleepers, placed so that the chairs will be five feet apart; the joint sleepers will be of oak or larch, and the intermediate sleepers of Scotch fir, which grows very abundantly in the country through which the line of Railway passes. The whole of the sleepers will be first soaked in Kyan's anti-dry-rot liquid.

SOUTHAMPTON RAILWAY BAR.

The section of the rail to be adopted on this line of Railway is precisely of the same form as the Birmingham rail, shown at Plate LXXVI. It is of the parallel form, and weighs seventy-five pounds to the yard. It was originally intended to adopt a bar of a very different cross section for the permanent rail, after employing it during the construction of the work. The following figure represents the section of this rail:—



	Inches
Depth of rail	$3\frac{1}{2}$
Thickness, centre rib	8
Breadth, lower flanch	$3\frac{1}{2}$
Depth of ditto	6

Weight .... 57 lbs. per yard.

Mr. P. Barlow, of the Royal Military Academy, made experiments upon the strength and stiffness of this (as well as two other kinds of) rail, with the proving-engine, in the Royal Dock-yard, Woolwich. The result of these experiments were given in a Report to the Directors of the Southampton Railway Company, dated November 9th, 1835. This Report is inserted in the new edition of Professor Barlow's valuable 'Treatise on the Strength of Timber, Cast-iron, Malleable-iron, and other Materials,' page 385. In the same work will be found a series of very valuable experiments on different kinds of rail, the deflection of railway bars, &c. &c.

The following is a Copy of the Specification for chairs and rails now in the course of being laid down on the Southampton Railway:—

SPECIFICATION OF CAST IRON CHAIRS.

The chairs to be of two kinds, double and single; the former being required for the end bearings of the rails, the latter for the intermediate bearings; they shall each be cast from No. 2 strong grey iron, or from several descriptions of iron possessing equal strength, and run from the cupola.

The joint chair will weigh about twenty-six pounds, and the middle chair about twenty-two pounds. Two middle chairs will be required for one joint chair.

The chairs shall be subject to the entire approval of the Company's Engineer; and any that he may reject, whether from an imperfection in the iron, or in the manufacture, shall be returned at the expense of the Contractor.

Tenders for five hundred tons, to be delivered in six months; the first portion of one hundred tons to be delivered within two months, and the remainder in each successive month afterwards.

SPECIFICATION OF MALLEABLE IRON RAILS.

The rails to be made from No. 2 Mine iron, free from cinder, so that when finished they shall be equal to No. 3.

Each bar shall be fifteen feet long, and weigh about seventy-five pounds per yard. The depth shall be five inches, the width of the upper and lower webs two inches and three-quarters, and the thickness of the middle thirteen-twentieths of an inch.

Every bar shall be uniformly free from warp, and straight; and the ends shall be squared, and cut smoothly off. The ends of every rail shall be filed or ground to the true sectional size, so that each may fill, and exactly fit the recess in the chair, and the Contractor must guard against compressing the rail by nipping it at the ends during the operation of cutting. The rails shall be perfectly manufactured; any appearance of imperfect welding, or of flaw in any part, will cause their rejection. The Company's Engineer, or other person to be appointed by him, shall possess the right of, and the manufacturer shall at all times give every facility for, inspecting the rails during the process of making; and the rails shall further be tested by the Engineer, and all those which he may consider imperfect shall be rejected.

The manufacturer shall be liable for all costs and charges upon those rails which may be delivered, and not accepted by the Company.

The rails to be delivered in London, or on a wharf to be provided by the Company on the River Thames, near Kingston, between the 1st of August and the 31st of December next. Tenders to state the place of delivery.

LONDON AND GREENWICH RAILWAY.

PLATES LXV. TO LXX.

THE London and Greenwich Railway Company was incorporated by Act of Parliament, on the 17th of May, 1833. The capital which the Company were empowered to raise for the completion of this work was four hundred thousand pounds, to be divided into twenty thousand shares of twenty pounds each; and in case the money so authorized to be raised by subscription should be found insufficient for the purposes of the Act, a power was granted to the Proprietors to borrow any further or additional sum, not exceeding in the whole the sum of one hundred and thirty-three thousand three hundred and thirty-three pounds, on the credit of the said undertaking, and of any lands, tenements or hereditaments belonging to the said Company. A second Act of Parliament was obtained on the 8th of June, 1837, entitled "An Act to enlarge the Powers of an Act, passed in the third year of the reign of his present Majesty, intituled 'An Act for making a Railway from London to Greenwich,'" whereby power was obtained by the Company to raise among themselves, or by the admission of new subscribers, any further sum or sums of money, not exceeding in the whole the sum of one hundred and fifty thousand pounds.

This Railway, which was designed and constructed under the direction of George Landmann, Esq., Civil Engineer, and formerly Lieutenant-Colonel of the Royal Engineers, has its commencement at Joiner Street, Southwark, near the southern extremity of London Bridge, and about one thousand one hundred and forty-four yards from the Royal Exchange, which is very nearly the centre of the metropolis. The approach to the Railway is by a sloped carriage-road, and well-paved footpaths: the Station, which is entered by handsome iron gates, is about four hundred feet in length, and sixty feet in breadth; it contains four lines of railway, which converge into two lines at about one hundred and thirty yards from the entrance. This Station will ultimately become the Terminus of the Croydon, Brighton, and Dover lines of railway, all of which are now in progress of construction, and will be connected therewith by means of the Croydon Railway, at a distance of about one mile and one thousand two hundred and seventy-six yards from the above Ter inus.

The whole length of the Greenwich Railway, when completed, will be less than four miles, and will, in this short distance, be one mile and three-quarters less than the turnpike-road, and effect a saving of time on each journey of fifty minutes over the former mode of conveyance.

The Greenwich Railway consists of a double line of rails, as shown in the Plan, Plate LXX., and, unlike all previous constructions of this kind, is wholly on a viaduct, mostly of brickwork, considerably elevated above the natural surface of the ground, which for the most part is below the level of high-water in the (neighbouring) River Thames. The arches of the viaduct are nearly all semicircular, eighteen feet in width, having piers four bricks, or three feet, in thickness, which is just one-sixth of the span; the arches are one brick and a half in thickness, excepting under the spandrell walls, where they are two bricks thick; the foundations, which vary in depth from three to twenty-four feet, rest upon a mass of concrete (composed of one part of lime and six of gravel). The extreme width of the viaduct is twenty-six feet, and the clear width twenty-two feet three inches: it has a parapet wall of the dimensions given in Plate LXX.; and at intervals of twelve arches, piers are constructed eight feet six inches in thickness, which are carried up several feet above the level of the Railway, and formed into convenient recesses for the work-people to retire into on the approach of a train.

At the present time (December, 1837) the works are completed as far as the High Street, Deptford, over which a cast-iron bridge is now in the course of erection. The arches of the viaduct are also constructed beyond that point to the western bank of the Ravensbourne Creek; and the foundations of several piers are in hand on the east side of the Ravensbourne. This stream is to be crossed by a lifting-

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bridge into the parish and town of Greenwich, where the eastern Terminus will be situated. At present the works consist of eight hundred and one brick arches, of which seven hundred and forty-nine are eighteen feet wide, and the remainder of various widths; also a very handsome iron bridge over Bermondsey Street; a second iron bridge, as before observed, is being erected at Deptford. The Bermondsey Street bridge consists of three openings; the middle one, or carriageway, is seventeen feet six inches wide on the square, and twenty feet high; the side openings, or footpaths, which are of the same height, are each of them six feet six inches wide on the square. Six cast-iron ribs, fifty-eight feet in length, extend over both the carriage and footways, and are supported by twelve cast-iron columns of the Roman Doric order, sixteen feet in height, six standing on a continuous plinth on each side of the roadway, separating the carriageway from the footpaths. Above each set of columns an iron tie runs from one side of the bridge to the other, and the whole is further strengthened by diagonal braces or crosses. The iron-work is covered with Yorkshire landings, upon which are bedded wooden plates; upon these rest longitudinal sleepers of timber, about sixteen inches by nine, connected together by iron straps and bolts. To the upper surface of the sleepers the cast-iron chairs which carry the rails are fixed.

The iron-work for this bridge was cast by the Messrs. Grazebrook, at their Works, near Dudley, and was put up by Mr. M'Intosh.

Twenty-eight of the brick, together with the two iron arches, are oblique to the general direction of the Railway, and are excellent specimens of this kind of arch. In Plates LXV. to LXIX. we have given plans, elevations, and sections of the oblique arches over the Neckinger and Spa Roads, which, together with the iron bridge before described, the two arches over Blue Anchor Lane, and those over the Grand Surrey Canal, are at present the objects of the greatest interest on the whole line. The following are the angles of obliquity of these and several other arches. These angles are formed by the abutments and the face line of the arches: —

	Degrees.	Minutes
Bermondsey Street Iron Bridge	36	15
Crucifix Lane (three arches)	69	50
Church Street, Bermondsey	67	46
Russell Street	69	20
Wellington Street	57	38
Neckinger Road (Plate LXV.)	48	21
Spa Road (Plate LXVII.)	52	23
Blue Anchor Lane	35	17
Grand Surrey Canal	42	41
Loving Edward's Lane	61	27
Church Street, Deptford	69	7

The rails are fixed at a gauge of four feet eight inches and a half; they are of the edge form, about two inches and one-eighth wide on the top surface, four inches and a quarter in depth, and one inch thick at bottom, and are in lengths of twelve and fifteen feet; they rest in cast-iron chairs at intervals of three feet, and are secured in their places by wrought-iron wedges. The chairs are fixed to rough blocks of granite or Bramley Fall stone, each containing about four cubic feet. Between the chair and the block thin pieces of elm plank are introduced. The cross section of the Greenwich rail is given in Plate LXXVI.

The bricks throughout are sound, hard burnt stocks, the greater part are from Sittingbourne. The concrete is composed of the best Halling lime and river gravel, in the proportion of one of lime to six of gravel, except in some of the deep foundations, when a rather larger proportion of lime was made use of. The mortar was composed of Halling lime and clean sharp river sand, from above bridge, in the proportion of one of lime to two and a half of sand. About nine courses at the crowns of the arches were laid dry and grouted. The whole of the brickwork was well grouted every course. The deepest foundations for the piers are at and near Wellington Street, and the shallowest are at and near the High Street, Deptford. The stonework on the line is principally of Bramley Fall, but a quantity of Cragleith has been made use of at the Ravensbourne, and at High Street, Deptford.

The whole of the work has been erected by Mr. Hugh M'Intosh, of Bloomsbury Square. The works, which had been for some time suspended, have been lately resumed, and the whole it is expected will be completed and opened to Greenwich for the public in May next.

The rails weigh fifty pounds per lineal yard; the chairs about eighteen pounds each.

The Railroad was opened to the public from London to Deptford on the 14th of December, 1836, and the number of persons who have *paid* to travel on the line from the 14th of December, 1836, to the 15th of December, 1837, is 1,462,591. This is exclusive of the passengers who have paid for quarterly tickets.

The greatest number of passengers who have passed on the line in one day, exclusive of the passengers with quarterly tickets, is 24,601, on May 16, 1837.

The greatest number passed on the line in one week was 76,775, week ending March 29, 1837. The next greatest number in one week is 76,121, in the week ending May 17, 1837.

There is a footpath formed at the foot of the arches from the Spa Road to Deptford, from which the Company receive a toll of one penny for each passenger using the same.

LONDON AND CROYDON RAILWAY.

Plates LXXI. and LXXII.

The Act of incorporation for the London and Croydon Railway Company, entitled "An Act for making a Railway from *Croydon* to join the *London* and *Greenwich* Railway, near *London*," was passed on the 12th of June, 1835. By this Act the Company were empowered to raise a capital for making and maintaining the said Railway, and other works authorized by the Act, not exceeding in the whole the sum of one hundred and forty thousand pounds, to be divided into shares of twenty pounds each; with power, in case the above capital be found insufficient for the purposes of the Act, to borrow, at interest, any further or additional sum, not exceeding forty-five thousand pounds, on the credit of the said undertaking. A second Act was obtained by the Company, on the 14th of July, 1836, entitled "An Act to enable the *London* and *Croydon* Railway Company to provide a Station and other works in the Parish of Saint Olave, in the Borough of *Southwark*, in the County of *Surrey*, and to amend the Act relating to the said Railway;" to defray the additional expense of such works, the Company were empowered to increase their capital by the additional sum of one hundred thousand pounds.

The London and Croydon Railway was projected by Joseph Gibbs, Esq., Civil Engineer, with a view to its forming the first ten miles of a Brighton Railway, and now in course of execution under his superintendence, commencing by a junction with the London and Greenwich Railway, at Corbett's Lane, a distance of one mile and one thousand two hundred and seventy-six yards from Joiner Street, London Bridge. A large space of ground between the Greenwich Railway Station and Tooley Street is now being cleared by the Croydon Railway Company, for the purpose of forming a depot, which will be brought up to the same level as the Greenwich Station by means of arches, and the warehouses and other necessary buildings may thus be formed with the advantage of double frontages, namely—in Tooley Street, on the present level of that street, and on the Station itself, at the level of the Railway.

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It is also the intention of the Company, either by themselves, or in conjunction with the Greenwich Railway Company, to widen the Greenwich Railway as far as the point of junction with the Croydon Railway. Whenever, therefore, the traffic may become too great for the present line, it will be possible to lay down two additional lines of rails, and thus the Croydon Railway Company may possess an independent line throughout.

At the spot where the Railway crosses the Grand Surrey Canal, about half a mile after leaving the Greenwich Railway, a large space of ground has been taken by the Company, and it is intended there to form a basin, with wharfs and landing-places for the delivery of heavy goods, which may thence pass down the Grand Surrey Canal into the River Thames; and as this Railway will be carried into a country, at present possessing few facilities for the transit of heavy goods, it is expected that by means of the Grand Surrey Canal, and the communication it affords with the River, large quantities of heavy goods will be brought along this line for the consumption of the districts into which it may be carried. There is also to be a Station at New Cross, on the Dover Road, and another one of considerable extent at the Terminus at Croydon, on the north side of the town, adjoining to the London Road.

The junction with the Greenwich Railway is effected by a viaduct of brick arches, which is carried on for a short distance, and joined by an embankment about twenty-four feet in height, extending as far as New Cross. The viaduct, in order that its appearance may harmonize with that of the Greenwich Railway Viaduct, is constructed on a similar architectural design. In the course of the embankment the Railway is carried over the Grand Surrey Canal by a bridge of three oblique arches, the centre arch over the waterway having forty feet span. The line then takes the direction of the Old Croydon Canal, the whole of which property has been purchased by the Railway Company. At New Cross, the Dover Road is carried over the Railway by a bridge of a single arch, formed of curved cast-iron girders (Plate LXXI.); the parapet walls are, however, supported by arches of brick set in cement, and the bridge, when viewed from the Railway, presents the appearance of a very flat brick arch, thirty feet in span, with a versed sine of two feet, or only one-fifteenth of the span. The road Commissioners having bound the Company not to raise the old road more than two feet, in order to comply with this, and, at the same time, to maintain as much head room as possible above the Railway, it was necessary to construct this bridge with an arch of very small curvature.

Beyond New Cross the Railway enters a considerable cutting, being then on the western side of the Canal, as the curve which it would be necessary to adopt, in order to confine the line to the Company's Canal property, would be inconsistent with those now adopted on main lines of Railway.

The amount of this cutting is about five hundred and thirty-eight thousand cube yards, its greatest depth seventy feet, and its mean depth about thirty-five feet.

The hill itself is situate in the London Clay Basin, but the material of which it is composed is not of the same objectionable character as that found in Highgate and Harrow hills, nor is it intersected to the same extent by springs of water, since it rests immediately on the chalk.

Notwithstanding, however, that the New Cross cutting possesses few of the dangerous characteristics of the London clay, the slopes adopted are two horizontal to one perpendicular; and at this slope the sides, so far as the excavation is at present made, appear to stand well, and to be in no danger of slipping.

About three hundred thousand yards will be taken from this cutting to the embankment north of New Cross, and the remaining quantity will be placed in spoil. The deposit of the spoil and the formation of the embankment are both proceeding rapidly (December, 1837), the Company having let this work on contract some months ago.

The Railway is carried through this cutting, and beyond it for some distance, on an inclination of one in one hundred, thus at once raising it upon a table land over which the rest of the line is nearly level, and

from which the various contemplated branches and extensions may commence their course with all the advantages of having, by means of the Croydon Railway, at least one summit less than they would otherwise have to surmount.

At the distance of about three miles seventy chains from its commencement, the Railway arrives at its summit level, being then one hundred and sixty feet above high-water mark; and from this point to Croydon the inclination of the Railway nowhere exceeds eight feet per mile.

From the end of the deep cutting at New Cross, the line passes by Brockley Green on to Forest Hill, skirting it on the east side, and then passes through Sydenham, across Penge Common and Selhurst Wood, terminating, as already described, on the north side of the town of Croydon. This is known to be one of the most beautiful environs of London; the high country near Forest Hill commands extensive prospects; and as it will be easily accessible from crowded parts of the town, it will doubtless become one of the most favourite, as it will be one of the most pleasant, rides from the metropolis. After passing the deep cutting near New Cross, the works are extremely slight throughout the last five miles; at the Croydon end there is not more than a quarter of a mile either of cutting or embankment exceeding twenty feet in depth. The whole of the embankments are finished with a top breadth of thirty feet, and with uniform slopes of two to one.

The following is a Table of the gradients on the Greenwich Railway from London Bridge, and then on the Croydon Railway to Croydon; from which it will be seen, that, with the exception of the inclined plane already mentioned, the whole line is on an inclination nearly equivalent to a level.

GRADIENTS ON THE GREENWICH RAILWAY.

Miles.	Chains.	
0	51½	falling 1 in 756, or 7 feet per mile.
0	75	„ 1 in 1232, or 4 feet 3 inches per mile.

ON THE CROYDON RAILWAY.

1	21½	falling 1 in 2222, or 2 feet 4 inches per mile
2	49	rising 1 in 100, or 53 feet per mile.
0	35	level.
1	4½	rising 1 in 660, or 8 feet per mile.
1	24	level.
1	4½	falling 1 in 660, or 8 feet per mile.
1	12	level
10	37	whole distance from London Bridge to Croydon.

The system of laying down the permanent road on this line differs materially from that adopted on many other important Railways.

The reasons which gave rise to a departure from the established practice, are to be found in those serious objections which have always attached to the system of disconnected supports given to the rails by means of blocks and chairs, instead of a continuous support by means of an uninterrupted bearing from end to end.

The difficulty of retaining the stone blocks firmly on their beds, so as effectually to resist the force which is continually applied to displace them; the liability of the chairs to become loose on the blocks of stone, and of the rails to become loose on the chairs, constitute some of the objections to the present system; nor is the increased weight of iron required in the rails, where they are only supported at intervals of three, and in some cases of four or five feet apart, a consideration by any means to be overlooked.

Experience seems to require, that a substance possessing some elasticity should be placed between the rail and the sleeper; and Mr. Gibbs has determined on the adoption of a system, which he thought would

entirely obviate, or at least very much modify, the objections we have stated, and at the same time secure the advantages to be derived from the presence of such a substance; with this view, and after mature consideration, in conjunction with Mr. Vignoles, he resolved to dispense with the use of chairs entirely, substituting in their place, and that of the stone blocks, a timber platform or foundation, composed of sleepers and longitudinal side timbers for the rails to rest upon, as represented in Plate LXXII.

The broad base of the rails is firmly screwed down to the longitudinal bearers, since it has been found that this is a much more effectual way of securing stability than by spiking down, as at first intended. Accurate and careful observations have been made on the effect produced by heavy weights passing over the permanent way, and so minute is the vibration which has taken place, that the particles of dust at the joints of the rails have not been shaken out.

The superiority in this respect appears to arise from the circumstance, that the whole system of the timber platform, and the rails supported by it, is capable of yielding in a slight degree to the weight passing over it. Thus, it is never without the necessary elasticity; and at the same time the yielding which takes place is uniform, and no one part is more deranged than another, while the elasticity of the whole system is the means of restoring it to its original position; and, further, by means of the transverse sleepers, the perfect parallelism of the lines of rail is maintained. It should be remarked, that by elasticity here is not meant any flexibility which would approach to a bending of the rail, but only such as would prevent that wearing tremulous motion which is produced by the contact of two non-elastic bodies when passed over by great weights at very high velocities.

From these causes it is anticipated that the wear and tear of this system will be very trifling in extent.

The Specification for the timber foundations adopted on the Croydon Railway provides ballast eighteen inches deep, and thirty feet wide at top, on which sleepers of the best Memel fir timber are to be laid at every lineal yard of railway, measuring from centre to centre, each sleeper to be eight feet three inches long, nine inches wide, and four inches and a half thick; on these sleepers are to be placed timbers of the same quality, also nine inches wide, and four inches and a half thick, running longitudinally, and secured to the sleepers by iron bolts and oak trenails, precisely as shown in the accompanying Plan; the rails are fastened on the side timbers with screw-bolts eighteen inches apart, agreeably to the Drawings.

The following detail shows the cost of the work for a double line of road, actually laid down according to this Specification, so far as it has proceeded: —

	£	s.	d.
Two sleepers in every lineal yard 3520 × 8 feet × 9 inches × 4½ inches = 7920 feet.			
Four rows of longitudinal side timber 21,120 feet × 9 inches × 4½ inches = 8752 „			
16,672 at 2*s.* 6*d.*	2084	0	0
Iron rails* forty-eight pounds per running yard of single rail, in one mile 337,930 lbs. at £14 per ton	2112	0	0
Trenails, 7040 in a mile, at £2 10*s.* per 1000	17	6	0
Bolts, 7040 „ at 3*d.* each	88	0	0
Screws, sixteen in every yard, or 28,160 in a mile, six of which weigh one pound = 4692, at 6*d.*	117	6	0
Ballast, one foot six inches deep, average breadth twenty-six feet, or four cube yards in every lineal yard = 7048 in a mile, at 1*s.* 6*d.*	528	12	0
Labour, laying and fixing, per mile	264	0	0
	£5211	4	0

* It is obviously a consequence of the system here described, that a much lighter rail will be required than when the supports are only placed at intervals. It is calculated that a forty-eight pound rail, of the Figure shown in the Drawing, and supported on the timber foundation here described, is more than equivalent to a seventy-five pound rail, supported at three feet intervals.

DESCRIPTION OF PLATES.

Plate LXXI. represents an elevation, transverse and longitudinal sections, and a ground-plan of the New Cross Bridge, which, as already stated, carries the Dover Road over the Railway. The materials used in the construction of this bridge are hard grey stocks and Merstham lime, with copings of granite, the back of the abutments and of the wing-walls being filled in with concrete. The joints are raked out one inch deep, and re-pointed with cement. The cast-iron girders are proved to a pressure of ten tons each, which weight they are required to withstand without flexure. They rest on courses of Bramley Fall stone, eighteen inches thick, into which they are sunk to a depth of one inch and a half. Sheets of felt, immersed in boiling tar, are placed between the joints of the stone and iron girders, and also between the bridging plates and the ledges of the girders, by which method all vibration is cut off from the brickwork. The spaces between the girders and over the bridging plates are filled in with bricks and cement.

Plate LXXII. represents a section and plan of the rails and sleepers. The character of the rails, and the mode of laying them, have been before described.

The hand-barrow or go-cart is used for the purpose of conveying earth, either down a slight declivity or over a level, along short leads, such as bridge approaches, or very short shallow cuttings, over a light temporary rail. The body will contain about three quarters of a yard of earth. The tail-board is slung at the top, the bottom being secured by means of a pin and catch, the latter of which is attached to a lever passing under, and extending to the front of, the barrow. On reaching the extremity of the teeming place, the man, by a slight horizontal movement of the lever, loosens the tail-board, and the earth is thus discharged with great facility and dispatch.

This hand-barrow was designed by Mr. Thomas Hughes, and has been extensively used by him on several large works, particularly on the Caledonian, and the Edinburgh and Glasgow Canals, in Scotland, &c. The object intended to be effected in its introduction, was the application of manual labour to the removal of earth in a more economical way than by means of the common wheelbarrow. At the time these hand-barrows or go-carts were introduced, the practice of using iron rails for the passage of earth waggons was very uncommon, and the wheels were, therefore, adapted to run on wooden planks. The labour of the workmen employed in moving the cart was found to be decidedly less than that of wheeling a common barrow. On the ground of economy, it was also found that where it was regularly used instead of barrows, the earth could be removed to the distance of a stage of about eighty yards in length for about the same price as an ordinary stage of wheeling twenty-two yards in length.

BIRMINGHAM, BRISTOL, AND THAMES JUNCTION RAILWAY.

Plates LXXIII. and LXXIV.

This Line of Railway, which was designed, and is now being constructed under the direction of William Hosking, Esq., was at first proposed to facilitate the access to and from the extreme western and south-western districts of the metropolis, and the London and Birmingham and Great Western Railways, and open a direct and economical communication for the trade of those great lines of Railway to the commercial parts of London, since their common Terminus, in a remote northern suburb, was alike inconvenient for the passenger traffic of the districts referred to, and for merchandise and produce to be delivered at, or received from, the markets, wharfs, warehouses, and docks, which lie upon and near to the River Thames, in its course through London.

The present limits of this proposed Railway, according to the Act of Parliament passed in 1836, are the Basin of the Kensington Canal, at the south end, and the London and Birmingham Railway, near Holsden Green, at the north end; and joins the Great Western Railway near the Paddington Canal, at Wormwood Scrubbs. It is proposed ultimately to extend this line to some eligible place as near to the west-end of Piccadilly as can be obtained, to give to the inhabitants of Westminster, and the court end of the town generally, the advantages of railway communication to the north and west of England, the Termini of the London and Birmingham and Great Western Railways being in the more northern suburbs of the town; Knightsbridge Green is the place at present fixed upon, where it is also proposed to establish a market in connexion with the Railway. A further contemplated object of this line of Railway, is to open a communication with the north and south of England, and also with France, by extending the line from the present proposed Station at Kensington Crescent, to the Southampton Railway near Wandsworth; by this means a traveller from Birmingham to Southampton will have reached Wandsworth Common, five miles from London, on his way to the latter town, as soon as the train by which he came from Birmingham will have reached the Terminus of that Railway at Euston Square.

When the Birmingham, Bristol, and Thames Junction Railway was first proposed, the Great Western line was to have joined the Birmingham line near Holsden Green, and the trade of both lines to have used the same railway to the Station at Euston Square; under these circumstances, the object to be attained in laying out the Thames Junction line was to have taken the most direct attainable course between the above-named point, near Holsden Green, and the Kensington Canal Basin, between which there is a difference of level of 100·5 feet; and the distance, a few chains short of three miles, a line drawn from one point to the other would not have given a good gradient, even if it had been attainable, which it was not, inasmuch as it would not have cleared the Paddington Canal and the turnpike-roads; it became necessary, therefore, to concentrate the rise, or a great part of it, on one inclined plane, and this might have been done by passing the Railway over the Canal upon the level of the Birmingham line for the first twenty-nine chains, southward of its junction therewith, and then form an inclined plane, to be worked by fixed power to such a point, that the line might be practically level from the foot of it to the Canal Basin; or, a similar inclined plane might be formed from the Birmingham line, at once to pass under the Canal to a similar point, and from thence as before, to the Canal Basin. The former mode was objectionable, as it divided the whole length, in itself short, into three sections, requiring three modes of traction, or a disadvantageous use of one sort of tractive power over two of the sections. The other mode would have made the earthwork very heavy, and all to go to spoil, though it gave the means of concentrating the rise at one end, and so simplifying the whole arrangement.

It was at length resolved to adopt the latter plan with some modification, to prevent any interference with the navigation of the Canal, &c., such as turning its course, as shown at Plate LXXIV.; and the works

were about to be commenced, when the Great Western Railway Company resolved upon applying to Parliament for powers to continue their line into London, and there (at Paddington) to have a Terminus independent of that of the Birmingham Railway, partly on account of their determining to adopt a wider gauge for their rails. The Great Western would now cross the Thames Junction Railway at Wormwood Scrubbs; and an arrangement was made between the two Companies, whereby the Great Western pledged themselves to establish a Station at the point of crossing, and to stop their trains for the interchange of traffic, &c.

It now became necessary to revise the section, as the rails of the Great Western were upon the same level with those on the inclined plane at point of crossing, from which point to the rails on the Birmingham line was a rise of thirty-eight feet; this was determined to be accomplished as before, with short inclined planes worked by fixed power, from the foot of which, to the Uxbridge Road, a practicable working gradient could be obtained, leaving the rest of the line, to the Basin of the Kennington Canal, very nearly level.

The general plan, at the points of intersection of the Birmingham, Bristol, and Thames Junction Railway with the Great Western Railway, the Paddington Canal, and the carriage-road, is given in Plate LXXIV. The Railway passes under the Canal by means of a gallery, shown in Plates LXXIII. and LXXIV. This gallery is one hundred and ten feet long, with lofty entrances, the clear heading being fourteen feet three inches above the rails, with a clear breadth of twenty-four feet at the shoulders, or springing, of the arch: the headway may appear restricted, but locomotive engines, with chimney, will not have to pass through it, and the height given is more than enough for every species of traffic. As this gallery forms the only direct and exclusive means of communication between the two Stations belonging to the same Company, a corridor, or footway, is formed, in connexion with the Railway gallery, so that all danger from that source may be avoided, and business be transacted without restraint.

North of the gallery, at the foot of the inclined plane leading to and from the London and Birmingham Railway, and west of the line of the Junction Railway, is a deep siding for the canal traffic. This attains the level of the wharfs by a short separate inclined plane, at the head of which the fixed power is placed for working both inclines, instead of being placed at the head of the former. Reference to the general plan above referred to will show that a part of the old line of the Canal is retained as a basin or dock peculiar to the business of the Railway, the northern towing-path of the new cut being carried into the old one on that side by a towing-path bridge across the entrance to the basin. As the wharfs to this basin or dock are valuable, and as the arrangements connected with them must not be interfered with by any thing extraneous, the carriage-road running along by the Railway from north to south must be kept on the east side of it. It is, nevertheless, required, that it shall be brought to the west side of the Railway in some places, and by a communication not less than thirty feet wide; and it must be carried over the Canal by a bridge of that width also. It was, therefore, deemed advisable to do *both* in *one*—to carry the road over the Railway and the Canal at once, by a bridge spanning the Canal obliquely where the Railway passes under it. The plan of the road bridge, Plate LXXIII., shows the arrangements to effect this object at large. The bend in the road through the obliquity of the bridge may appear objectionable, but it will be found that this gives the diagonal instead of two sides of a parallelogram, which must have been traversed to obtain the same end in any other way.

The span of the bridge is seventy feet. It might have been restricted to about sixty-five feet, by narrowing the towing-paths to the Canal, and making the angles of intervention more acute, and the line of the road across it less distant; but the present was adopted as a medium. The bridge is of a peculiar construction, and may be denominated an iron-arch suspension bridge, which is in its construction the converse of a chain suspension bridge. It is, and has been, most extensively used by Mr. Leather, of Leeds. There are two such of that gentleman's construction at Leeds, both across the River Aire, the one, Monk Bridge, spanning one hundred and twelve feet, and the other, Huntslet Bridge, one hundred and forty feet between the abutments, each consisting of two ribs only, and the roadway, or floor of the bridge in each, being thirty-eight feet. Mr. Leather is now constructing a magnificent aqueduct on the same principles of construction, to convey the Aire and Calder navigation over the Calder, near Wakefield. This span is one hundred and fifty feet.

The bridge over the Paddington Canal, and the Birmingham, Bristol, and Thames Junction Railway, at Wormwood Scrubbs, has a carriageway of twenty feet wide, two footways of five each, and the platform of the roadway is suspended from four ribs instead of two, as in Mr. Leather's bridges. The ribs are made proportionably lighter, and it is believed that they distribute the weight more equally upon the piers, and may be braced to more effect in this manner. It is thought desirable too to guard against the effect of a large concourse of people assembling on one side or the other of this bridge, because the locality renders such a contingence probable.

Plate LXXIII. contains the plan and elevation of the bridge, at the point of intersection of the three lines of communication, namely, the turnpike-road, the Canal, and the Railway; the lower figures represent the transverse section of the bridge at the abutments, and also in the middle: in these sections there have been accidentally omitted, *raking or cross-braces*, between the pairs of ribs under the roadway. Plate LXXIV. contains a general plan of this very peculiar object, and also a plan and sections, &c., of the Railway gallery beneath the Canal. The details of the cast-iron crown to the gallery are given in Figs. 1, 2, and 3; the first being half the elevation, the second the plan, and the third the transverse section, showing how the several parts come together. The apparent slightness of the construction of the gallery is compensated by the use of Rhodes's compressed bricks, set in pouzzolana mortar, instead of common bricks in plain mortar, and the whole structure being bedded upon, backed up with, and filled in at the spandrells with brick rubble and Thames ballast concrete, as shown in the transverse section.

The erection of this interesting structure, the gallery and bridge, as shown in the above two Plates, have been undertaken by Messrs. W. and L. Cubitt, for the sum of £7,680.

GLASGOW AND GARNKIRK RAILWAY.

PLATE LXXV.

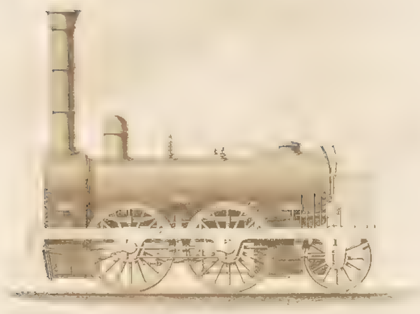
THIS Engraving represents the cutting through the moss or peat which abounds on this line of Railway, and we have introduced it to show the extent of cutting transversely, adopted by the Engineers, Messrs. Grainger and Miller, in executing so difficult a business, and which has perfectly succeeded. The cuttings through Robroyston Moss, Plate LXXV., was about two thousand seven hundred feet in length, and thirty feet in depth; so soft and spongy was the ground, that when a few feet in depth had been cut out, the ground on each side frequently slipped in while the operations were going on, and this cut may be said to have been three or four times excavated. The ground on each side of the line is not now more than five feet above the surface of the rails, the whole body of the moss, to the extent of about four hundred feet on each side of the Railway, has sunk more than twenty feet, chiefly from the water having been drawn off by the operations in the formation of the Railway at this point.

This Railway is thirty feet in width, and has a double line of rails, the gauge being four feet six inches; the rails are in about sixteen feet lengths, weighing for the most part twenty-eight pounds per yard, but in some places, especially through the mosses, the weight is thirty-six pounds, and are mostly of that form called fish-bellied rails.

COMPARISON OF RAILS.

PLATE LXXVI.

This Plate requires no description, it contains the transverse sections of a great variety of rails now in use, and forms a very curious and interesting record of some of the varieties of figure given to that great element in the *iron* age of science.



LOCOMOTIVE ENGINES.

It was many years after the first attempt to apply steam to the purposes of locomotion before it was satisfactorily ascertained, that the adhesion of the wheels of an engine upon the rails was sufficient to effect its progression; and many contrivances of various degrees of ingenuity were brought forward to produce locomotion without the aid of adhesion at all. It was in 1813 that Mr. Blackett, of Wylam, had an engine constructed which worked by the adhesion of its wheels on the rails only. "His railroad was a plate rail, and would, consequently, present more friction or resistance to the wheels than an edge rail; and, on that account, the amount of adhesion would be greater than upon the latter rail. Still the credit is due to Mr. Blackett, for proving that the locomotion could be applied by that means alone." Since which time the contrivances for facilitating locomotion have been numerous and highly successful; and, in the hands of George Stephenson, Esq., followed by other scientific persons, the locomotive engine has become a wonderful machine, and promises, by its almost magical effects, to take a large share in improving the social, moral, and political condition of kingdoms. Two of the most modern construction are represented in Plates LXXVII. and LXXVIII., of which the following are the particulars:—

'COMET' LOCOMOTIVE ENGINE.

Plate LXXVII. represents the 'Comet' locomotive, made by R. and W. Hawthorn, Civil Engineers, Manufacturers of Steam Engines and Machinery generally, of Newcastle-upon-Tyne, for the Newcastle and Carlisle Railway, being the first engine put upon that line. The cylinders are placed in a horizontal position, twelve inches diameter, and sixteen-inch stroke. The wheels are four in number, four feet diameter, coupled by side bars. The crank pins are fixed in the wheels, having no outside frame. The boiler is seven feet five inches long, three feet diameter, with sixty-six brass tubes, seven feet nine inches and a half long, and two inches exterior diameter. The fire-box is forty-one inches wide, twenty-one inches and a half long, and thirty-eight inches above the grate, having thirty-seven feet and a half of radiating heat, and two hundred and sixty-nine feet of communicative heat. The slides are worked by four fast eccentrics, first introduced into this engine by the manufacturers, instead of two loose ones heretofore used,

and the complicated machinery for reversing the motion, thereby materially simplified, and rendered much more secure, both as regards regularity of motion and its being less liable to derangement, which, with further improvements upon this principle, have been invariably used by these Gentlemen in their manufacture of other engines.

'THE HARVEY COMBE' ENGINE.

MR. STEPHENSON'S PATENT.

Plate LXXVIII.

Cylinders.	Diameter	12 inches
	Length of Stroke	18 "
Tubes 120 in Number—Internal diameter		1[illegible] "
Wheels	One Pair (driving wheels)	5 feet diameter.
	Two Pair	3 feet 6 inches ditto
Weight	When empty, nearly	10 tons.
	Of water, fuel, &c.	1 ton 18 cwt.

Total evaporating surface about 480 feet superficial—estimated to be about 50 horse power.

The following is a Specification of this kind of Engine, as required for the London and Southampton Railway:—

SPECIFICATION

OF LOCOMOTIVE ENGINE AND TENDER.

General Form.—The Engine to be constructed with two horizontal cylinders, working to a double cranked axle in the driving wheels, being similar in form to the 'Shark' now in use on the Grand Junction Railway

Wheels.—The Engine to be placed on six wheels; the driving wheels to be five feet and a half, and each of the other pairs three feet and a half in diameter; each wheel shall have a cast-iron nave, bound with two malleable iron-hoops, with malleable iron arms welded to the rim, upon which the tire, five inches wide and one inch and a half thick, shall be placed. The flange or rib on the tire shall not project more than one inch. All the wheels shall be turned to the true size, and a template of the cone of the wheel will be furnished by the Company's Engineer at the proper time.

Cylinders.—The cylinders shall each be thirteen inches in diameter, sufficiently long for a stroke of eighteen inches, and fitted with metallic spring pistons, of the most approved construction.

Boiler.—The boiler shall be cylindrical, three feet three inches in diameter, and eight feet long, and shall contain not less than one hundred and twenty of the best tough rolled brass tubes, one inch and five-eighths in diameter at one end, and one and three-quarters at the other, drawn on a mandrill. They shall be fastened into the boiler, with steel hoops, in the usual manner. The thickness of the tubes shall correspond with what is usually denominated No. 15 wire gauge; and the holes in the boiler ends shall be quite parallel.

Fire-Box.—The fire-box shall be of copper, seven-sixteenths of an inch thick, with the exception of the plate into which the tubes are to be fixed, which shall be three-quarters of an inch thick. The inside width of the fire-box shall be three feet six inches, length two feet six inches, and depth from the roof to the top of the fire-bars three feet four inches. The water spaces shall be three inches wide, and the roof and sides of the box shall be stayed with copper bolts, tapped and rivetted.

Axles.—The cranked axle shall be made of the best back barrow iron, five inches and a quarter in

diameter at the crank pin. It shall be turned down to three inches and a quarter for the outside bearings, and shall in other respects be made to a template to be provided by the Company's Engineer. The axle for the fore-wheels shall be three inches and three-quarters, and for the hind-wheel three inches and a quarter in diameter; they shall be turned throughout.

Framing.—The engine to be provided with four inside stay and bearing frames of wrought-iron, having brass bearings to fit to the main axle on both sides of each crank. For this purpose the axle shall be properly turned to suit these bearings, and the frames being connected with the fire-box and cylinder beds will form stays for their support. The outside, or principal frames, shall be made of well-seasoned ash plank, three inches thick and seven inches deep, plated on both sides with quarter inch best low moor plates. These frames shall be clear three feet two inches from the surface of the rails.

Feed Pumps.—There shall be two feed pumps of brass, fixed on the side of the boiler, having clear uninterrupted water spaces of two inches and a half in area.

Chimney.—The chimney shall be covered with a wire cap, and shall not be higher than thirteen feet from the surface of the rails. All the bearings or journals shall be case-hardened.

General Fittings.—The engine to be worked by eccentrics, with single slide valves and steel facings, and to be provided with two of the most approved safety-valves, water-gauges, buffers, draw-bars, splash-boards, ash pan, syphon cups, safety bars in front, wood sheathing, brass ball and socket, communication pipes, steel springs, and with every other article or appendage necessary for putting the engine into complete working order, according to the intent and meaning of this Specification.

Materials and Workmanship.—All the materials used shall be of the best description, and applied in the very best manner, and these, together with the workmanship, shall be subject to the approval of the Company's Engineer, who shall be at liberty to test each part, and put each engine to a working trial for a reasonable time (not longer than a week), and after his approval, it shall be paid for in cash. If the engine be not approved, the Contractor shall make such alterations or additions as the Company's Engineer shall direct.

Parts of Engines to be Fac-similes.—Ten engines are required, and it is desirable that they should be similar in their form and dimensions. It shall, however, be at the option of the parties wishing to contract, to tender for any number of engines not less than *three*, and the dimensions of all the parts of each shall be similar. The dimensions of the wheels, axles, &c., are required to be similar in all the engines; therefore, each manufacturer will be required to adhere strictly to the sizes given, so that these parts of any engines may, in case of necessity, be transferred to any other engine, whether made by himself or not.

General Directions.—It is not intended to confine the manufacturer to any detailed plan of arrangement, but no deviation from the general directions given in this Specification, or from the general form of the engine referred to, will be admitted without the sanction of the Company's Engineer; and the Contractor will be required, from time to time, to communicate to the Engineer the plan of arrangement he proposes to adopt, or of any alteration he may have to suggest; and it is desirable that all persons wishing to contract, should accompany their offer with a particular description of the engine they propose to build; and they are requested, previously to the day fixed for receiving the offers, to communicate their plans to the Engineer.

Tenders.—Ten engine tenders will be required, in form similar to those now used on the Grand Junction Railway. The frames shall be made of well-seasoned ash timber, with transverse and diagonal braces, well bolted together. The tank shall be of the horse-shoe form, capable of containing seven hundred gallons of water, made of iron plates five thirty-seconds of an inch thick, and provided with cocks and pipes to connect with the ball and socket feed pipes of the engine.

The wheels shall be of wrought-iron, three feet six inches in diameter, similar to those described for

the engines, with wrought-iron tires, one inch and a half thick. The axles and journals shall be similar to those at the fore end of the engine.

Each tender to be provided with springs, break, buffers, long elliptical spring and chains to draw by, with a box of tools suited to the engine, oil-cans, shovel, and other appendages to put it completely in a working state.

The general stipulations as to materials and workmanship given for the engines, to apply also to the tenders.

All the engines and tenders to be delivered at the Railway Station, Nine Elms Road, London, between the 1st of March and the 1st of May, in the ensuing year, under a penalty of three pounds per day for every day's delay beyond the 1st of May.

Sealed offers, stating the price for each engine and tender, separately addressed to the Secretary of the Company, must be delivered on or before the 10th day of July next.

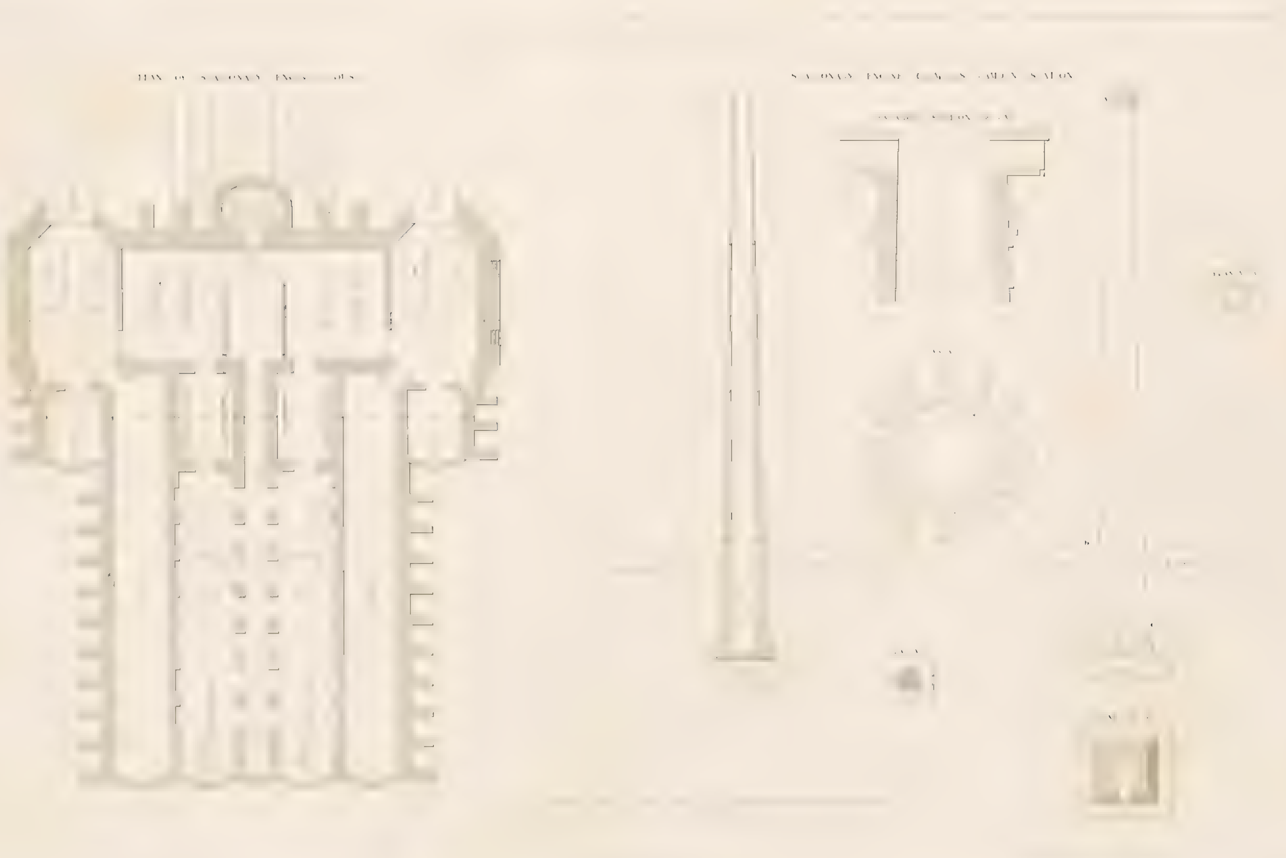
RAILWAY WAGGONS.

The waggons, as employed on the Colliery Railways, are represented in Plate LXXIX. Their construction appears too evident to need much description. The wheels are three feet in diameter, made of cast-iron: some of them have wrought-iron arms or spokes cast in the nave, with the outer ends dovetailed, which fit into mortice holes cast in the rim. The arms are made a little short when cool, but by heating them red-hot before they are attached to the rim, they are expanded to the proper length. The contraction which follows, when the heat subsides, after this attachment is made, reduces them to their original dimensions, and draws their dovetailed ends tight into the mortices of the rim, thus preventing the possibility of their working loose. The arms, when made of malleable iron, are less liable to be broken by shocks, or concussions, than those of cast metal. The rims of the wheels suffer much from friction on the rails. To prevent this the rims are case-hardened, by running the metal, in casting them, against a cold cylindrical band of iron. This is done where the rims are cast by themselves, without risk of breaking in cooling, which is not the case when wheels are cast in one piece. Sometimes the wheels are hooped with malleable iron tires, when the cast rim has been worn through. This plan answers a very good purpose, and may be resorted to at a small expense. The axletrees are made of wrought-iron, about three inches square.

Plates LXXX. to LXXXIII.

These represent different varieties of Rails and Passing Places, chiefly in use about ten or twelve years back, and are interesting, as they show by contrast the advance which this department of Railway Engineering has since undergone.

END OF DIVISION I.



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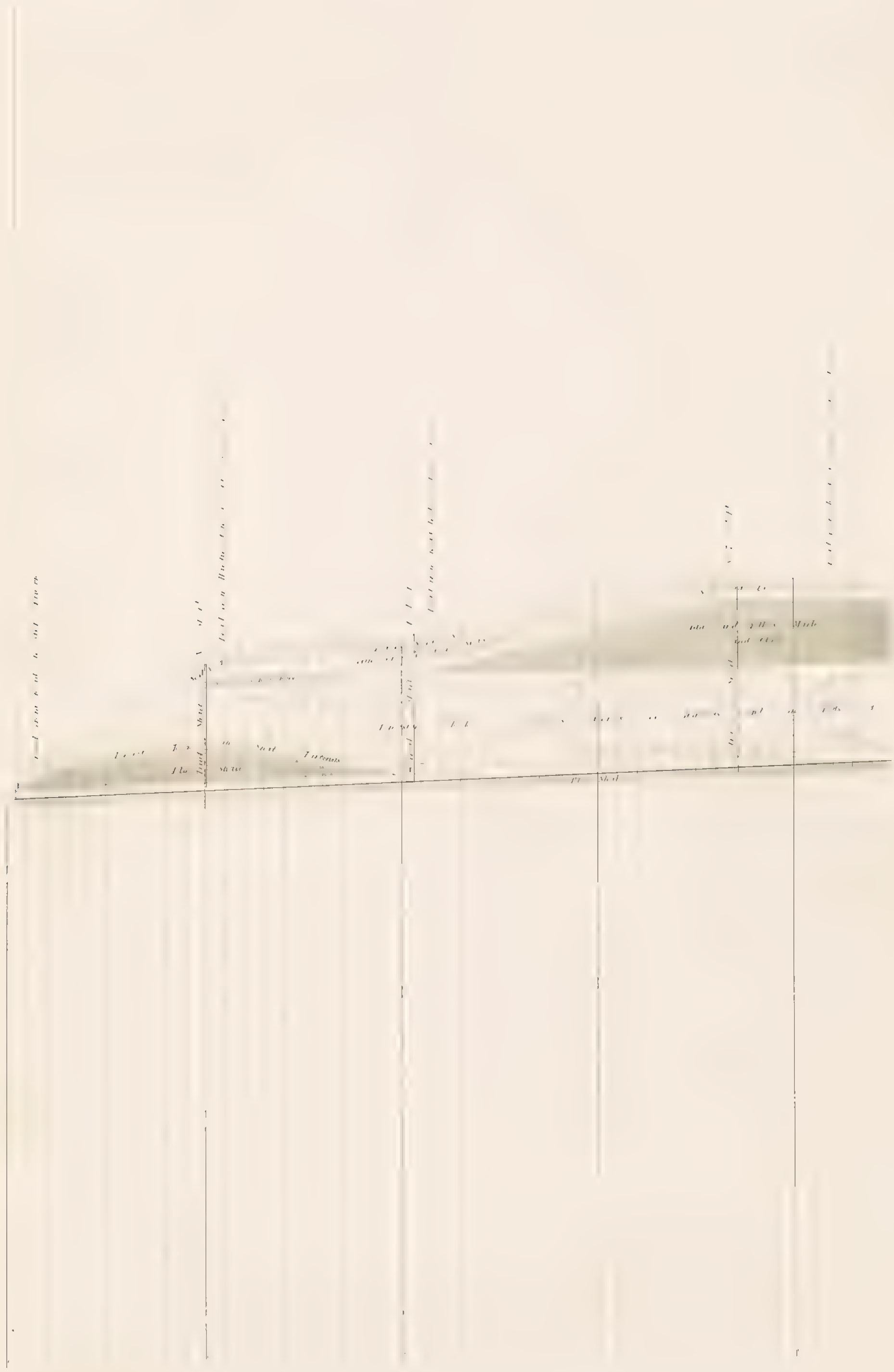
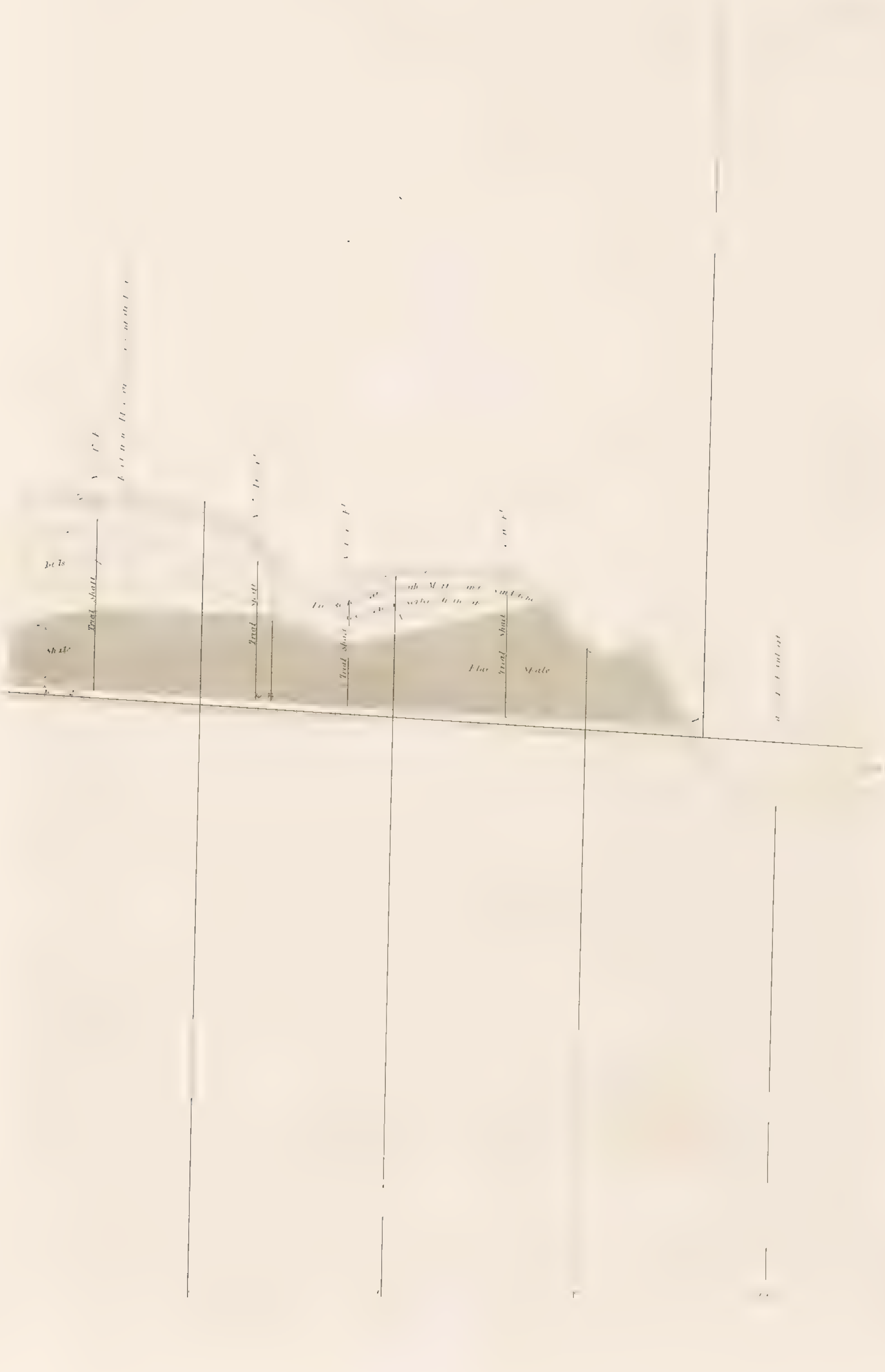
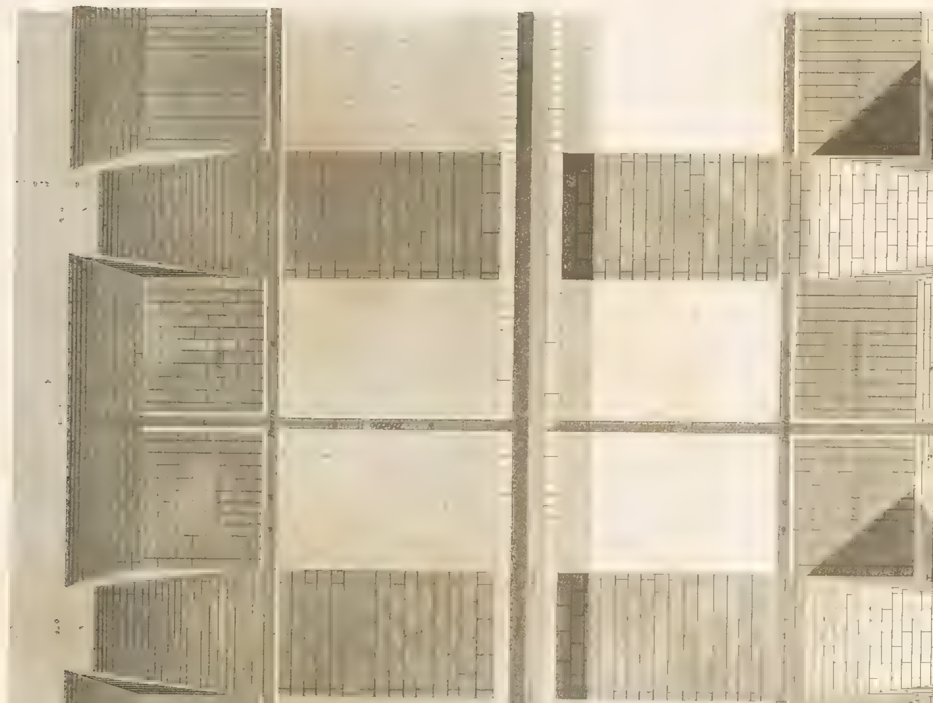
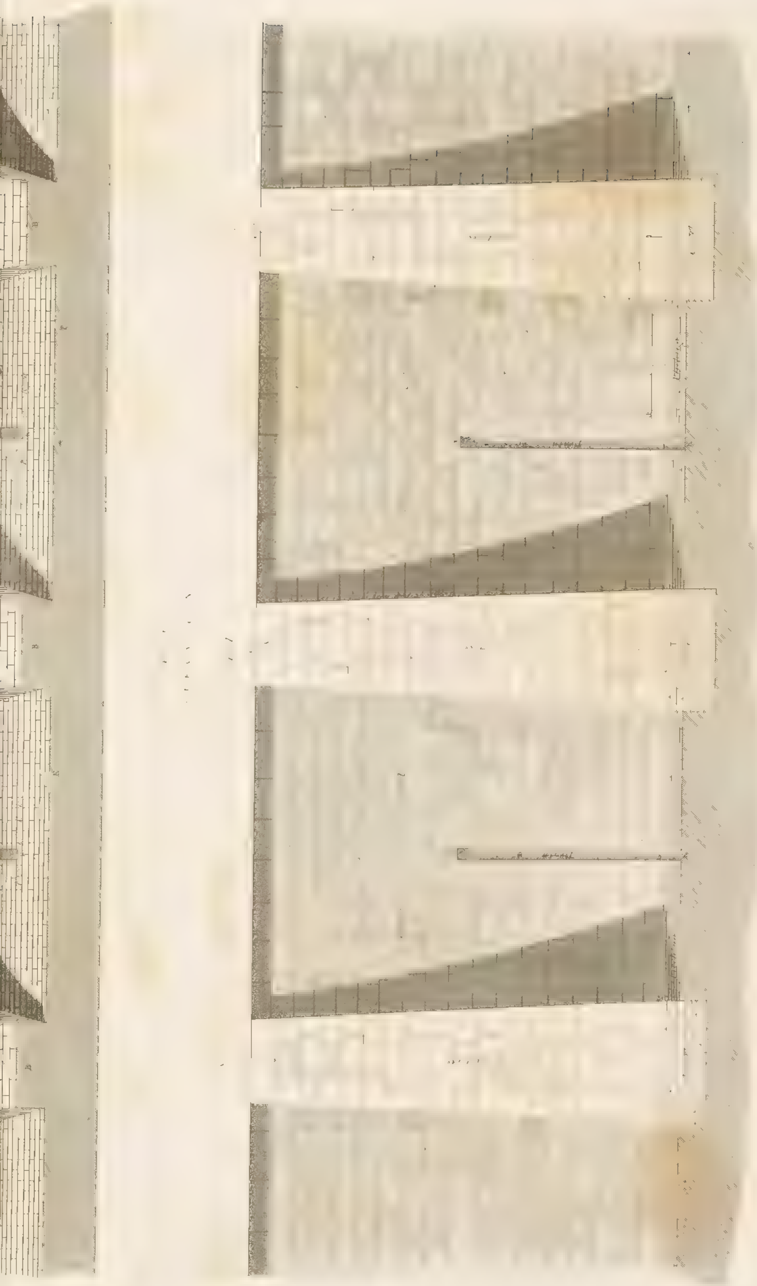
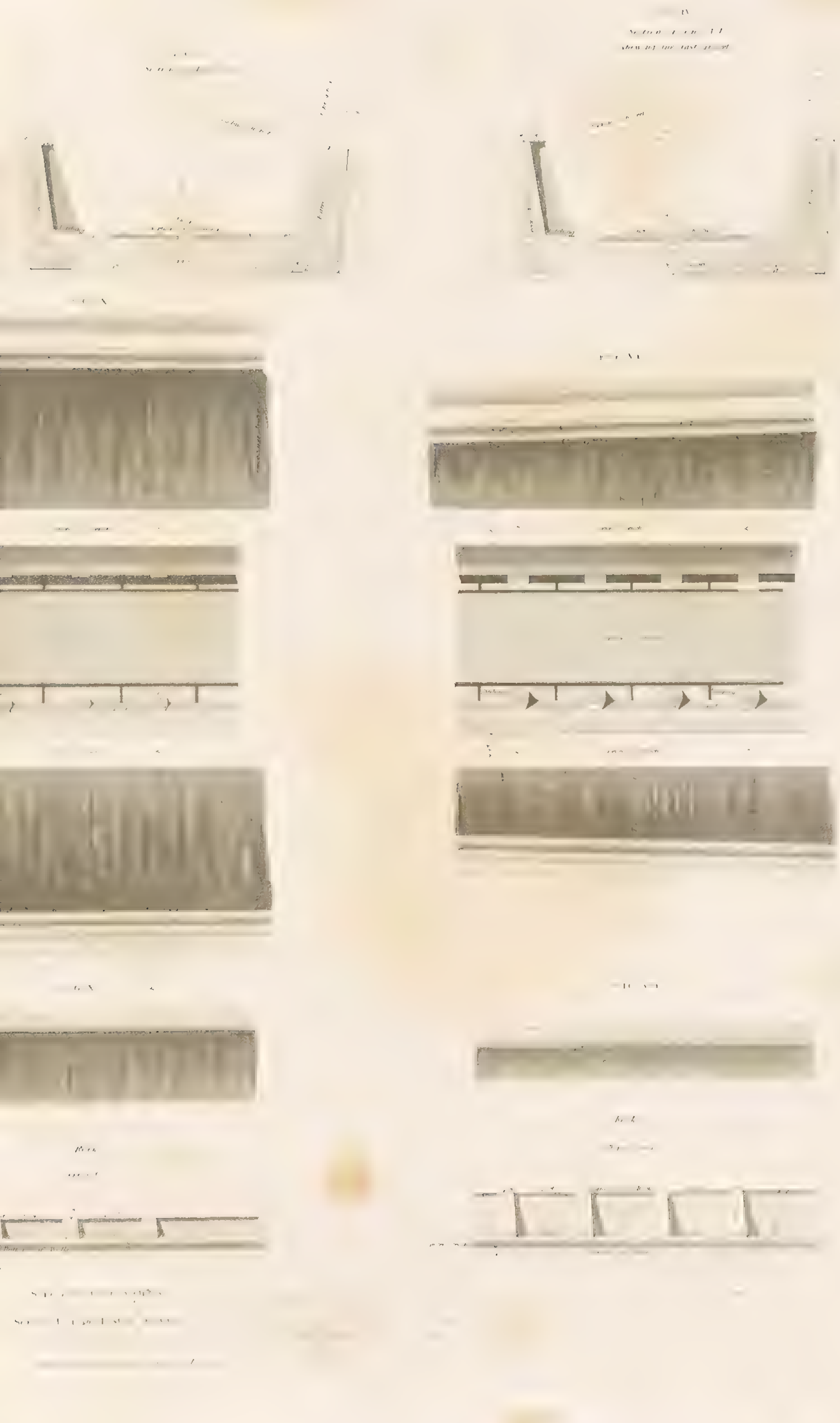
Blue
and
Green
Shale

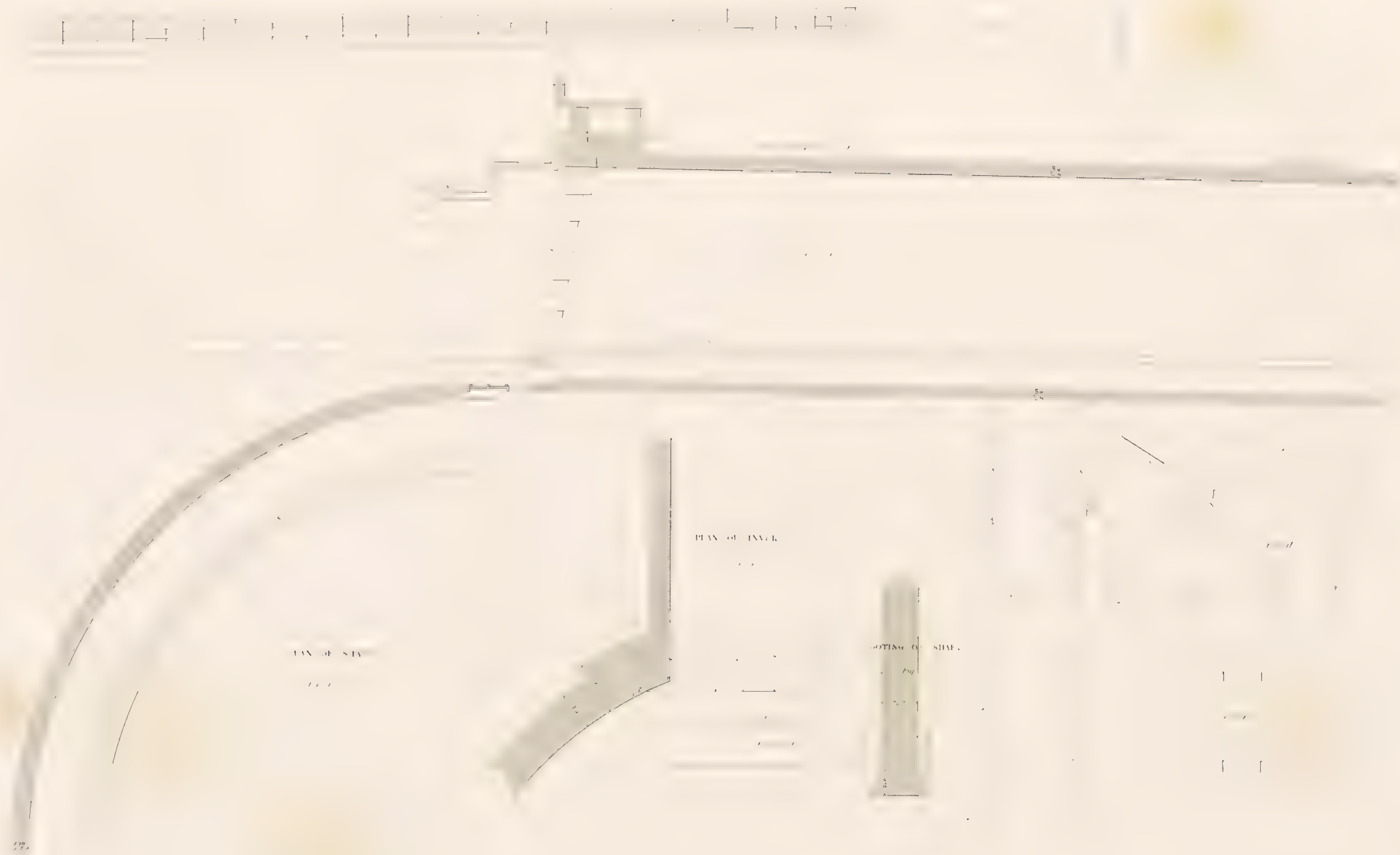


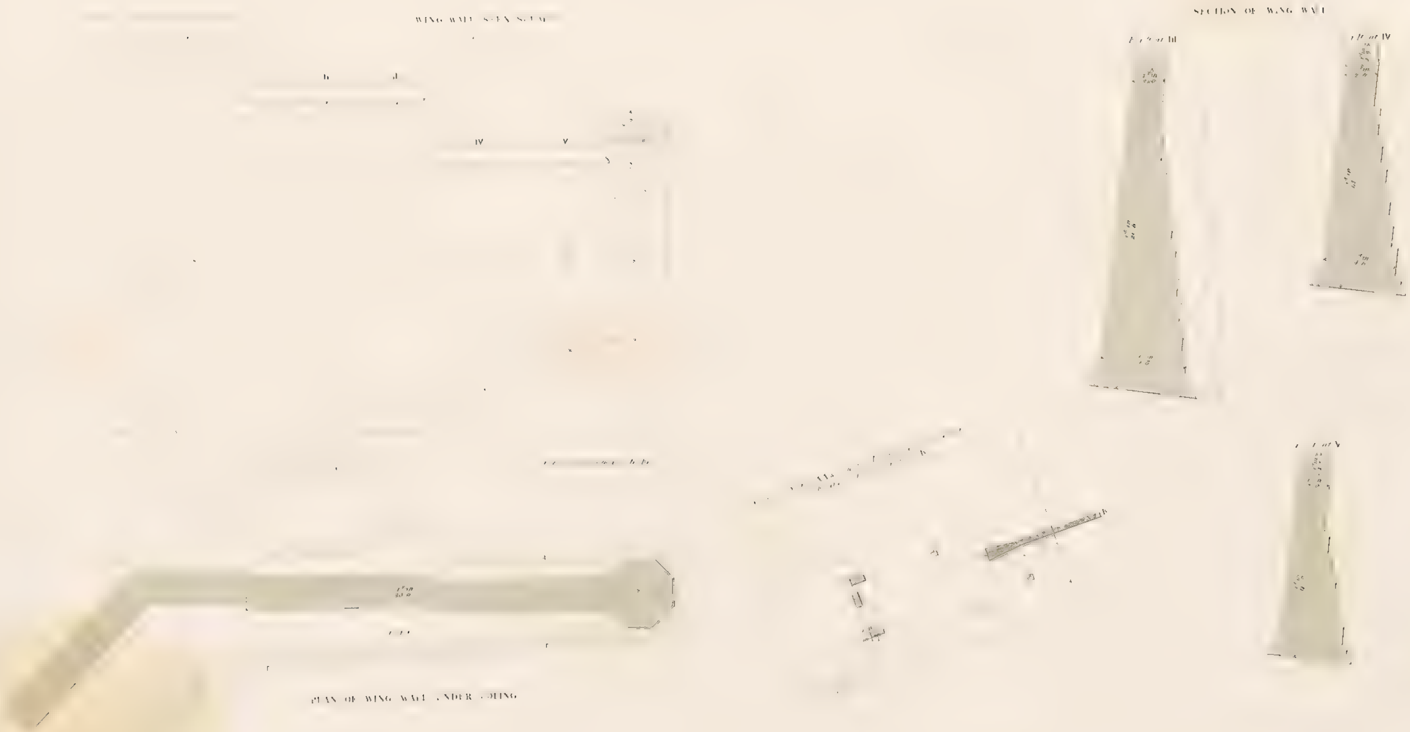


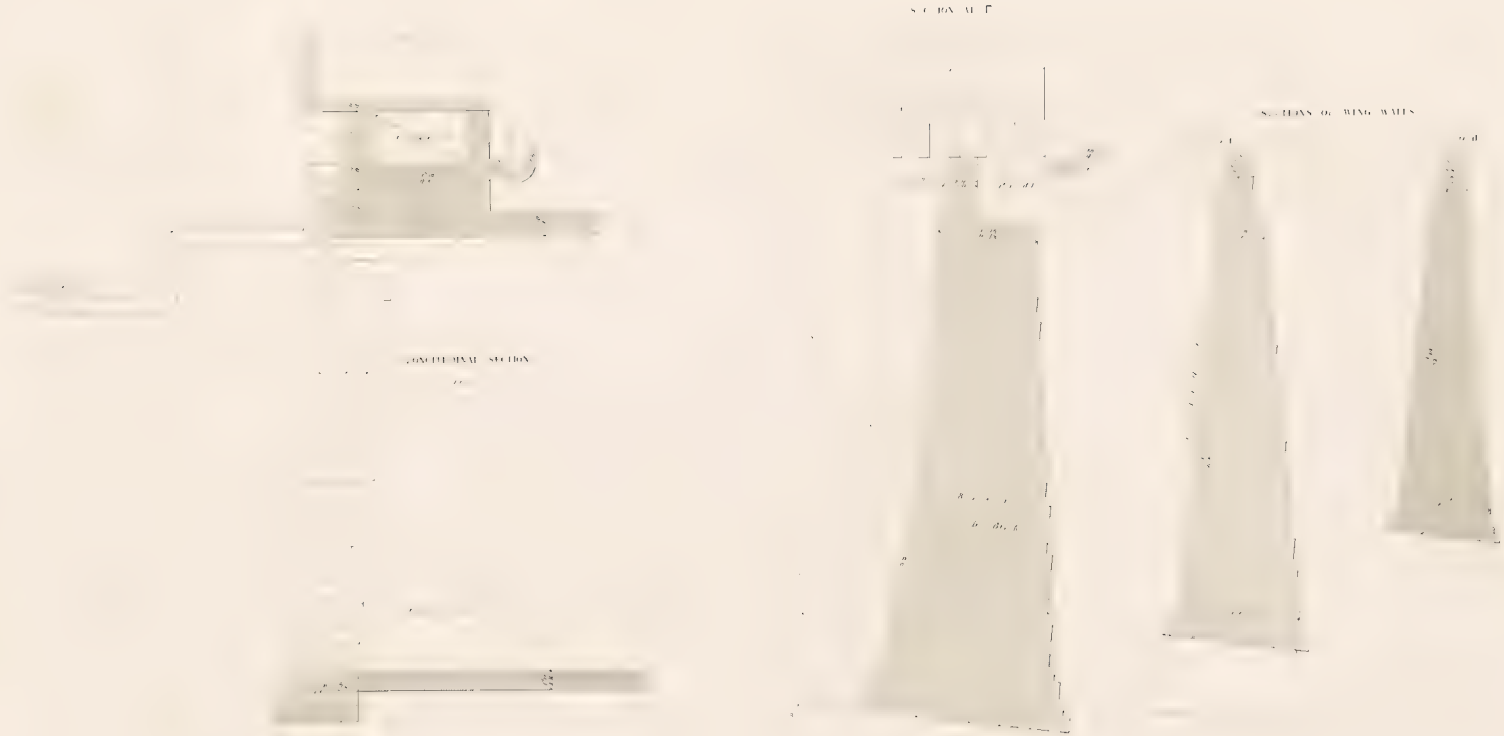




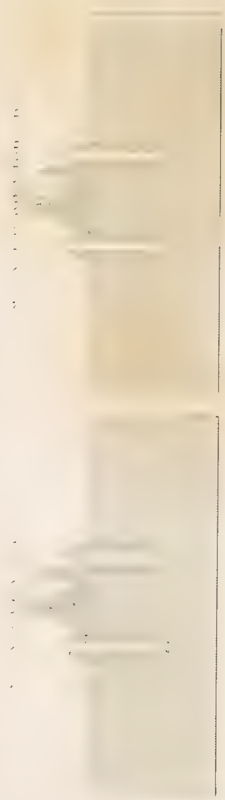


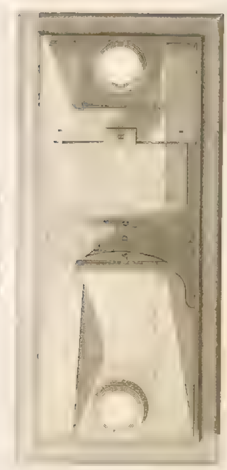


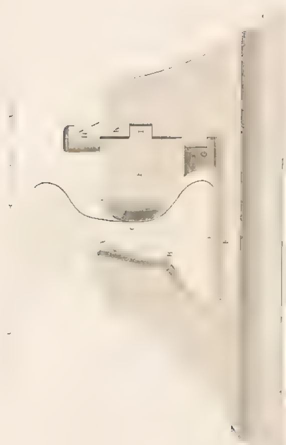

SECTION OF WING WALL

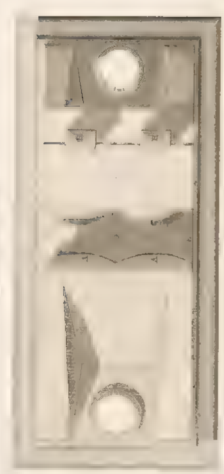

LONGITUDINAL SECTION
SECTIONS OF WING WALLS


Radius 40



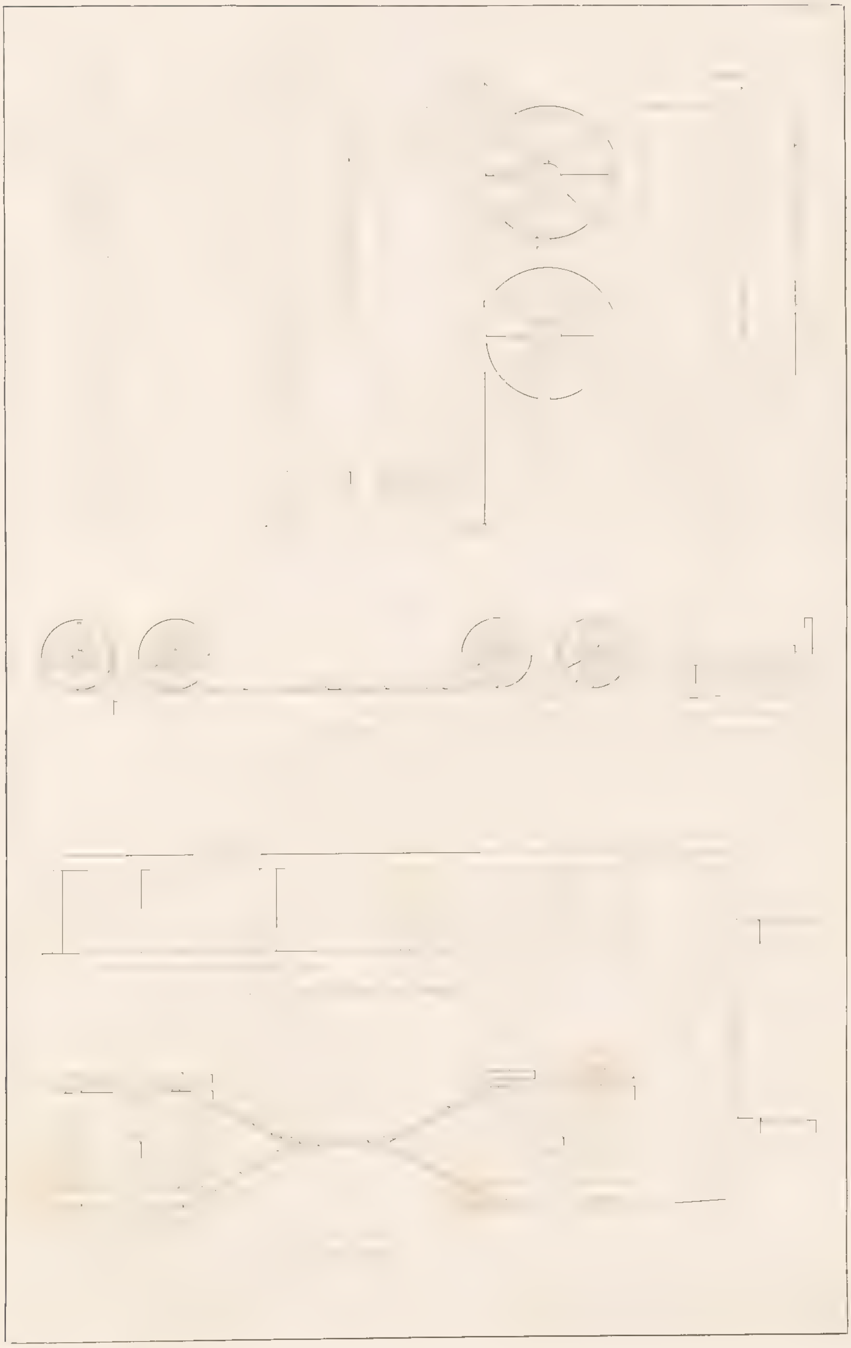


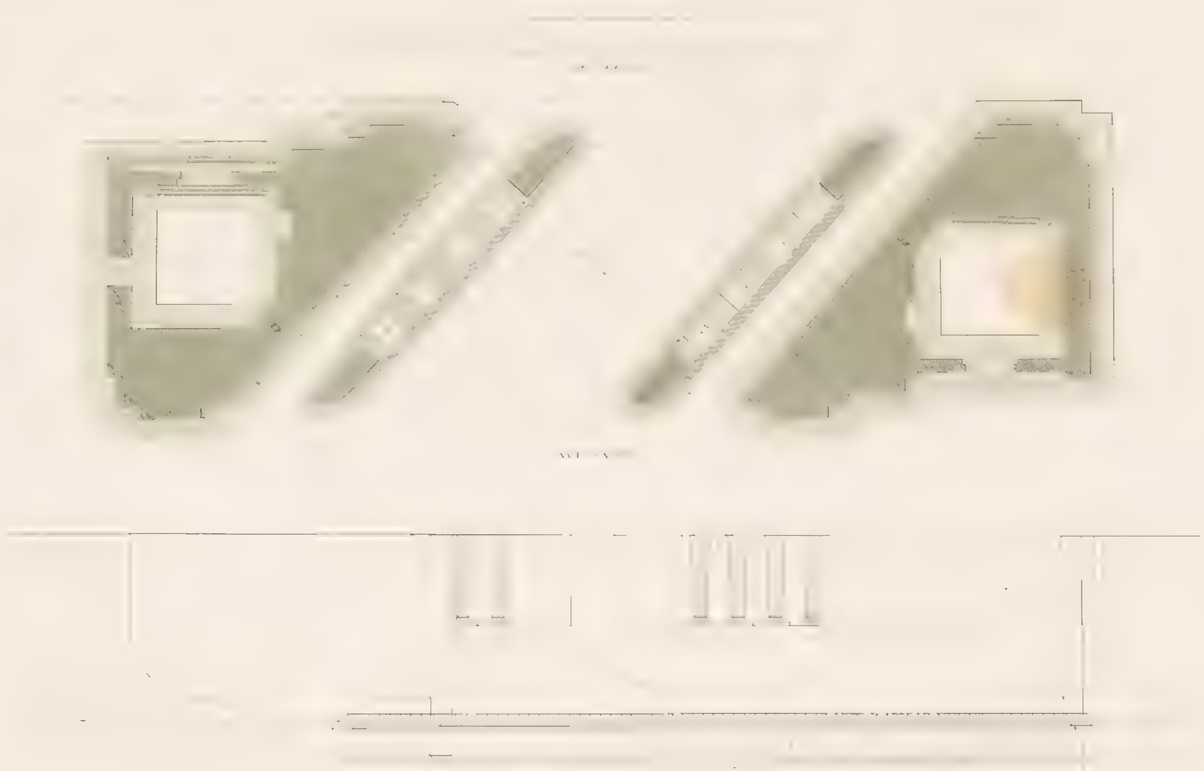


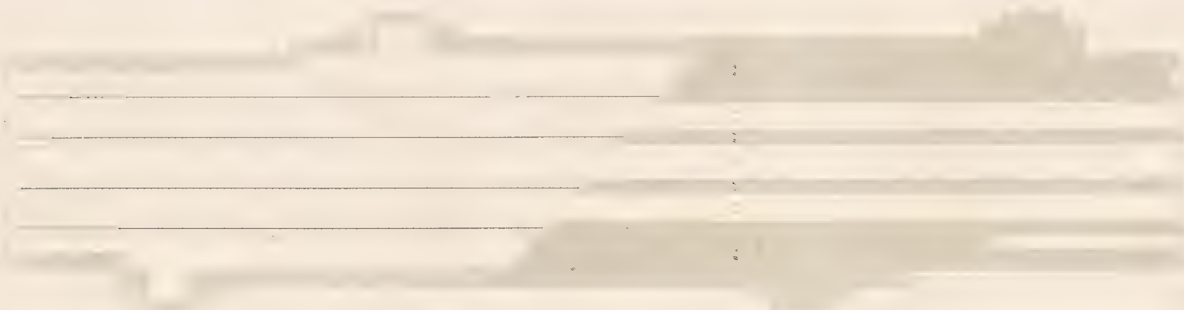


AN OCCUPATION BRIDGE OVER THE RAILWAY

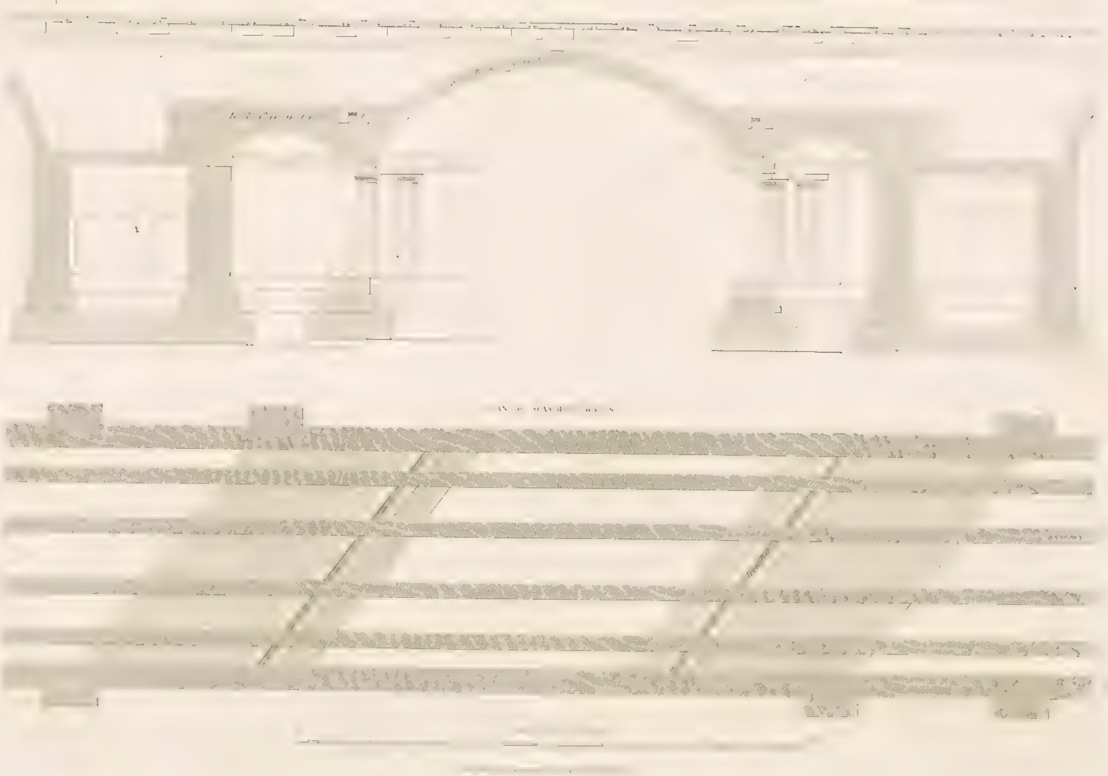
BRIDGE UNDER RAILWAY

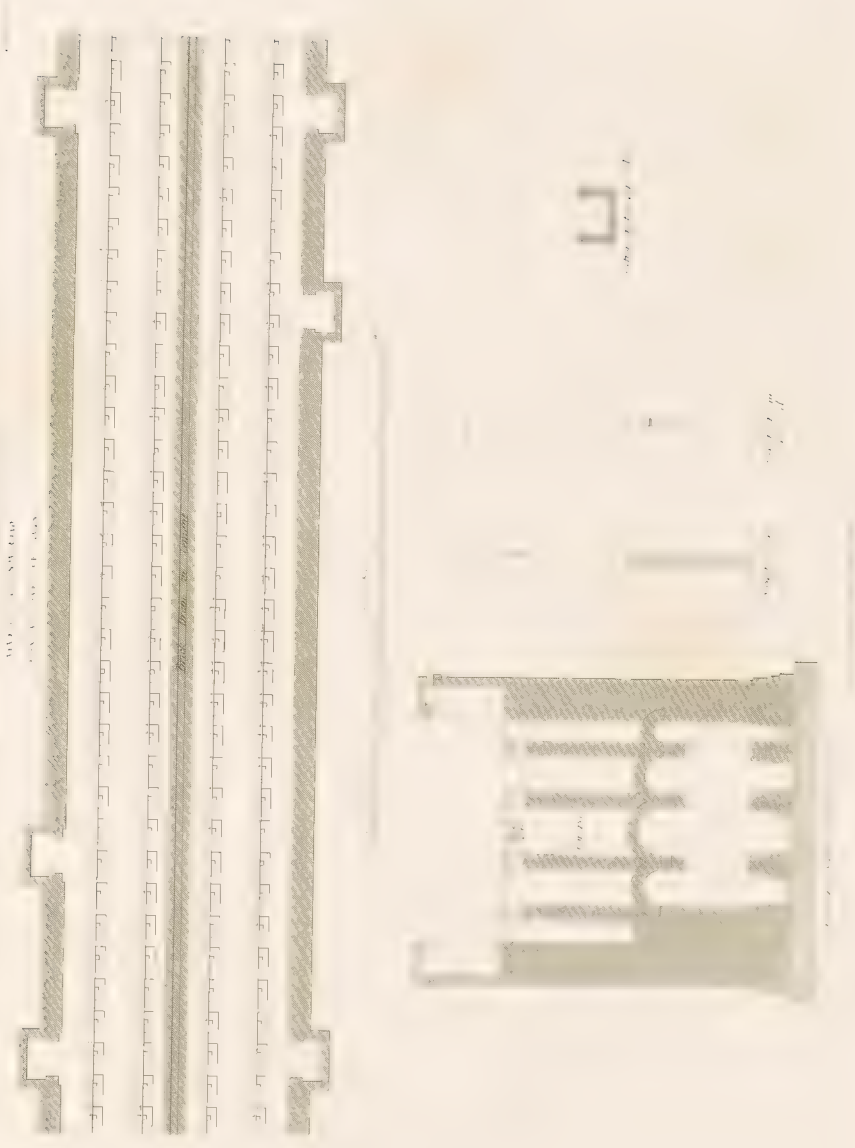


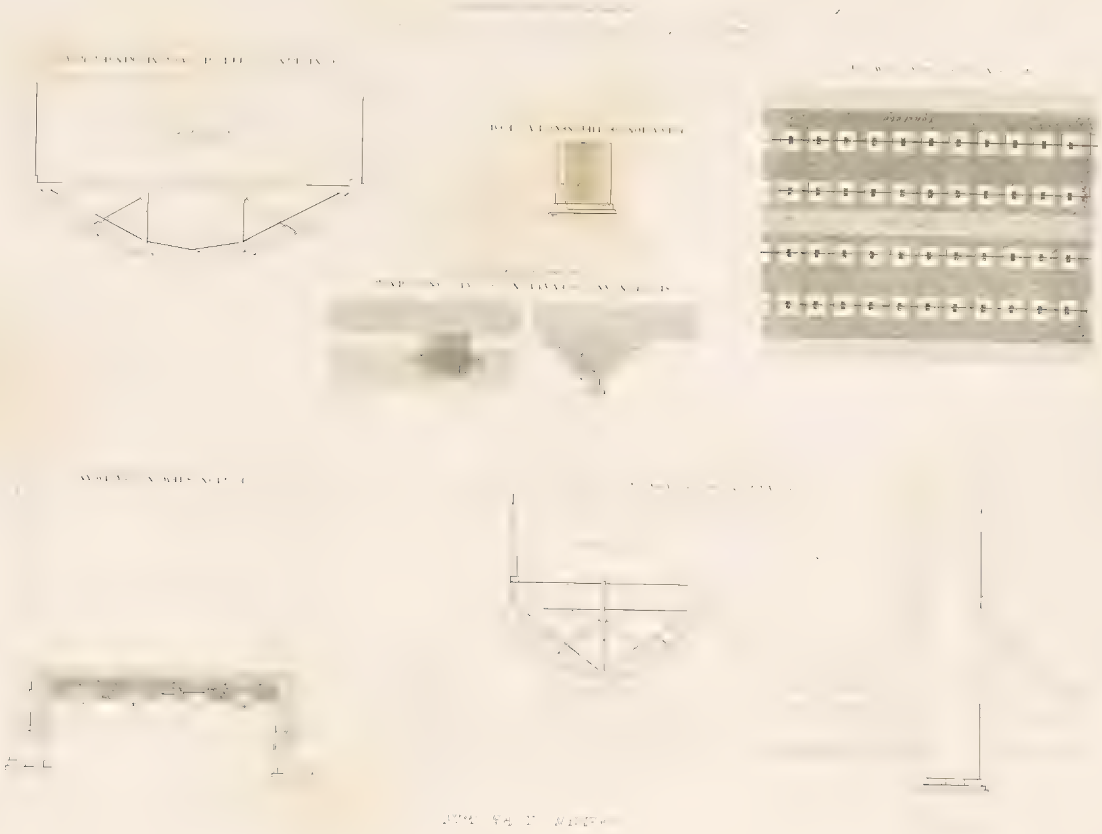


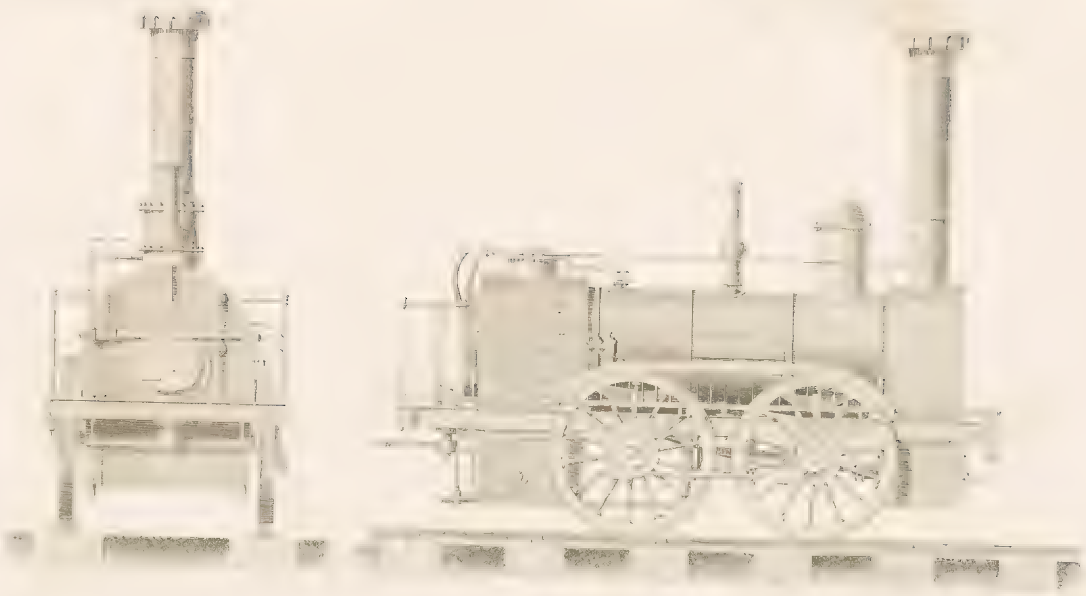


ARCH OVER SEA ROAD



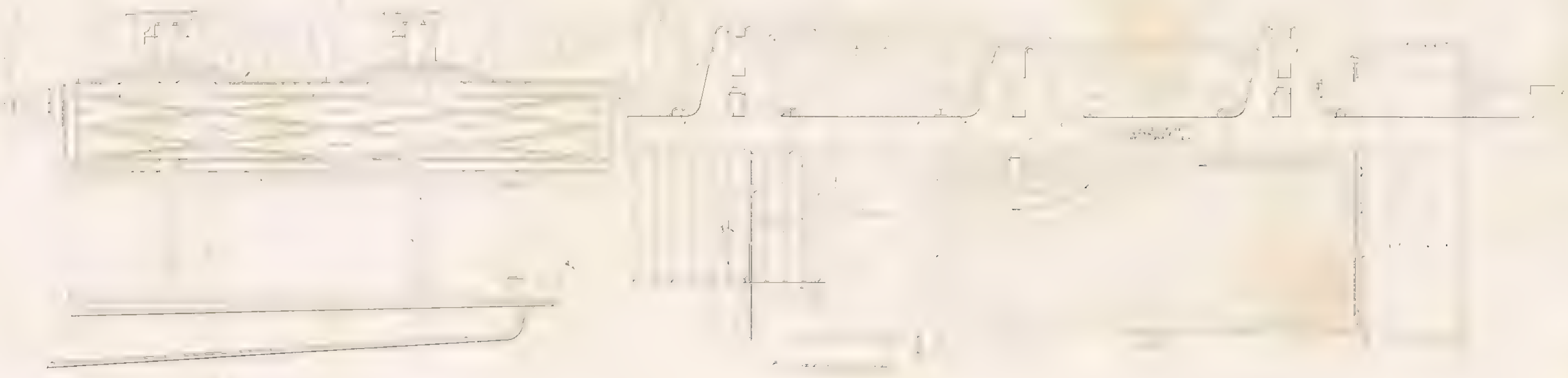

Brick Drain in Cement



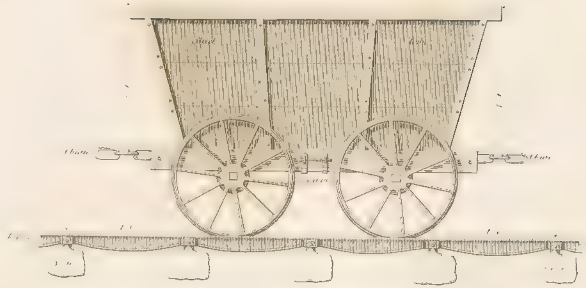


COMET LOCOMOTIVE ENGINE,

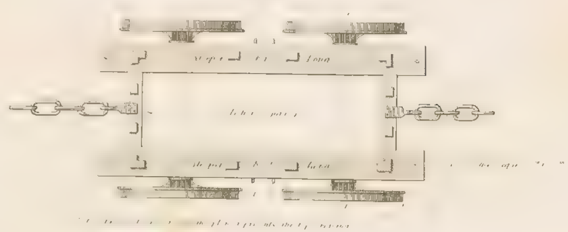
MANUFACTURED BY [illegible] BURY



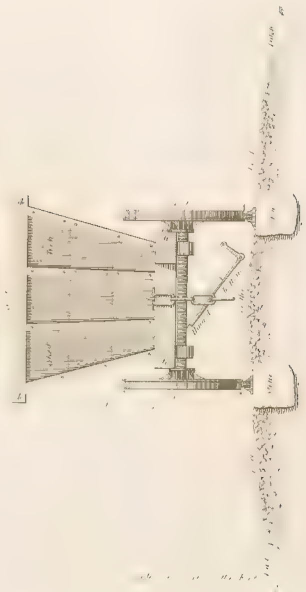
SIDE VIEW OF A WAGGON.



PLAN

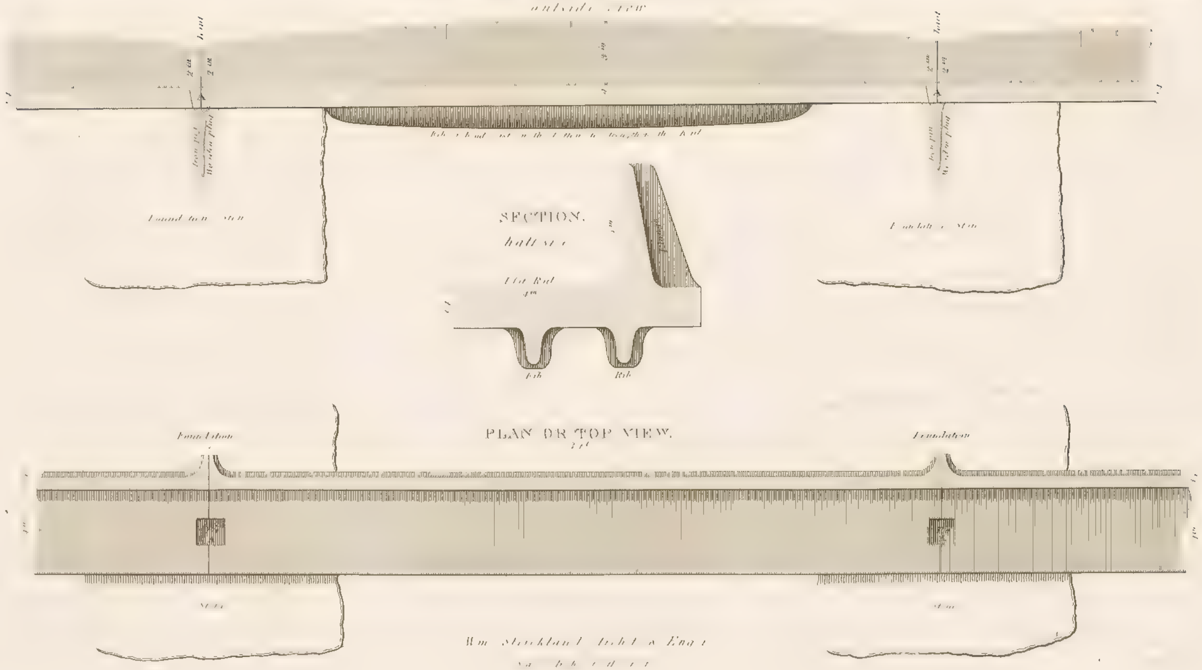


END VIEW



FLAT RAIL AND FLANGE.

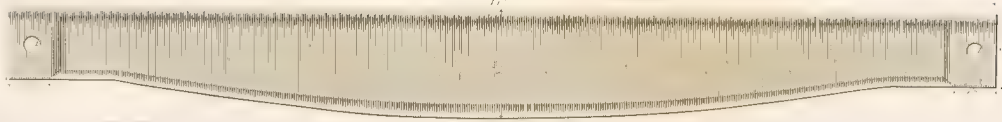
outside view



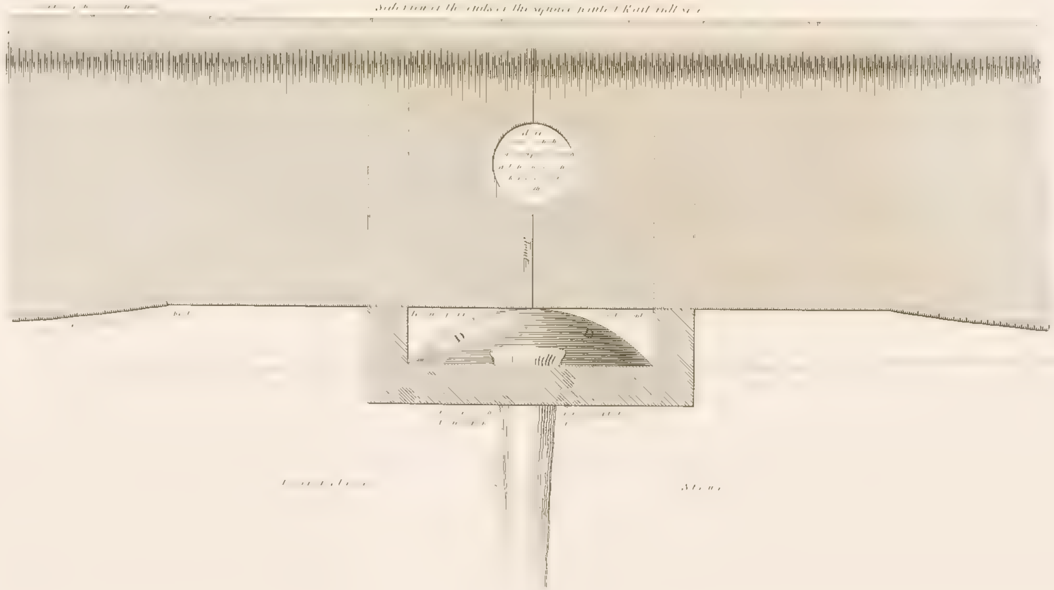
Wm Strickland Archt & Engr

LOSH WILSON & BELL'S EDGE RAIL.

Side view

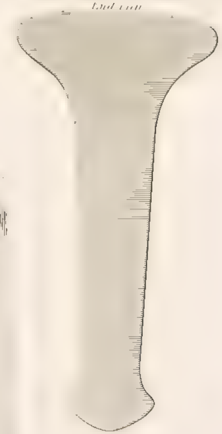


FAWDEN RAIL.



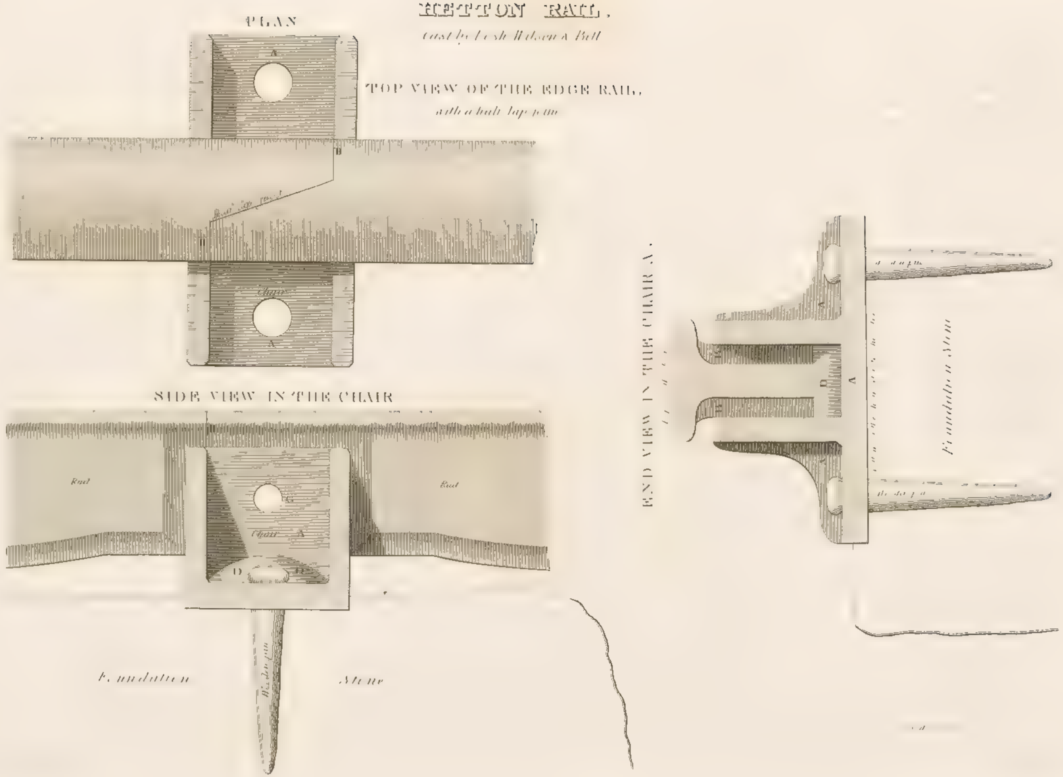
RAIL FULL SIZE.

End view

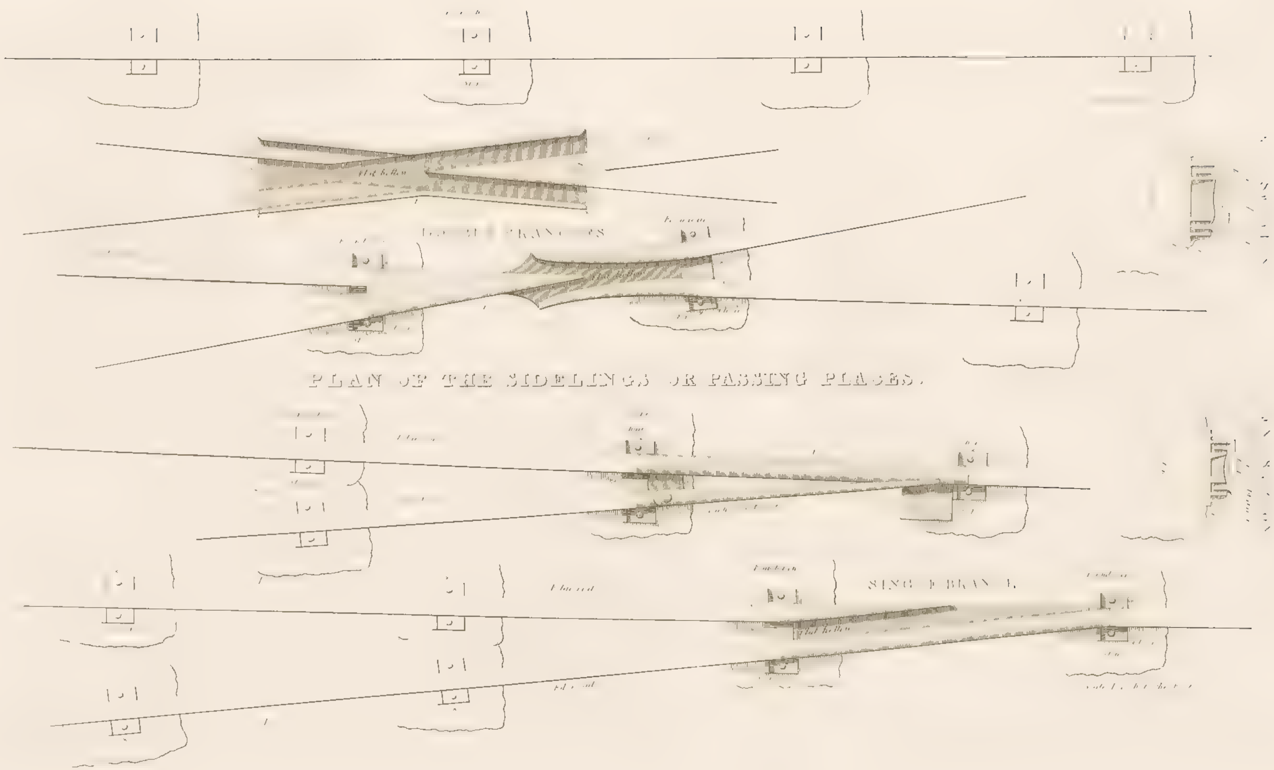


HETTON RAIL.

Cast by Losh Wilson & Bell



PLAN OF THE SIDELINGS OR PASSING PLACES.



PUBLIC WORKS

OF

GREAT BRITAIN.

DIVISION II.

COMPRISING

CANALS, BRIDGES, RIVER WALLS, AND THE DOCKS AND PORT OF LIVERPOOL.

THAMES AND MEDWAY CANAL AND TUNNEL,

PLATES LXXXIV to XCI.

The entrance to this Canal is from the River Thames, East of Gravesend, in the Parish of Milton. The River Lock here is capable of passing vessels of from 200 to 250 tons into the Basin, on the sides of which are commodious wharfs. From hence the canal, which is fifty feet wide, and has seven feet depth of water, passes through the marsh land to the village of Higham, where the Tunnel commences. The length of this part of the canal is about four miles and three-quarters. There are five cast-iron swing bridges, communicating with the lands on either side, and one oblique bridge built of brick, of forty feet span, which connects the villages of Higham and Chalk. The entrance to the Tunnel is a short distance from this bridge, and it continues under the chalk hills for a distance of two miles and a quarter, when it opens into a capacious basin, commanded by a large River Lock (Plates LXXXVII and LXXXVIII), forming a junction with the River Medway, East of Rochester Bridge. The whole length of the Canal and Tunnel, from its entrance into the River Thames, to its termination at the River Medway, is about seven miles ; and by this short line, all the circuitous and oftentimes dangerous passage round the Nore, and up the Medway, is avoided, thereby making a saving in distance of from forty to fifty miles.

The Entrance Lock, from the Medway, is capable of receiving vessels of 400 to 450 tons burden. This Lock has cast-iron gates : those at Gravesend were originally of oak, but all their lower parts having been eaten away by the worm, William Tierney Clark, Esq. the Chief Engineer to the Canal Company, was induced to suggest the use of cast-iron gates, which were subsequently adopted from his designs as early as the year 1819.

Several fruitless attempts had been made prior to the year 1819 to commence the Tunnel, and various plans were suggested for that purpose ; but in the month of April of the above year, the Directors approved of Mr. Clark's plan, and placed the whole of this stupendous work under his direction.

The nature of the soil through which the Tunnel passes is chalk and fuller's earth, combined with courses of flint. The surface of the ground is extremely undulating : (see Plate LXXXIV) from the

Higham Entrance it rises rather rapidly, to the elevation of 167 feet above the top water of the Canal; it then dips very suddenly to 85 feet above the same level; from this point, which is called the valley, the ground rises gradually to the summit of Strood Hill, where it is 191 feet above the water of the Canal, and from thence descends rapidly into the parish of Friendsbury, where the entrance of the Tunnel is formed in open cutting. From this great irregularity of the surface of the ground, and from its being thickly covered with brushwood, it was found exceedingly difficult to set out the line of the Tunnel. Mr. Clark overcame this difficulty, by the application of a transit instrument similar to those used for taking astronomical observations in Right Ascension. Upon the summit of the hill next to Higham a wooden observatory was erected, sufficiently high to command the Strood summit; and upon the latter summit was also erected a similar observatory, which commanded the Higham summit, and the Friendsbury entrance. The instrument was then fixed in the Higham observatory, and adjusted to a point on Higham Bridge, and then reversed on its axis to prove its correctness.* The two extremes being fixed, all the intermediate points must be in a straight line. The line being thus ranged between the summits and the extreme at Higham, the instrument was then fixed in the observatory, on the Strood summit, and adjusted to the range between the summits, which enabled the range to be continued down the Friendsbury Hill, to the entrance of the Tunnel; and by this method, a perfectly straight line was obtained over the whole undulating surface. It is necessary to observe, that some difficulties arose in the application of this instrument; for, after the line had been set out in the morning, and observations were made in the evening, they were so much at variance, that Mr. Clark was about to abandon the use of the instrument altogether, and adopt the old and uncertain mode of ranging; but having spent much time on the subject, he determined on continuing further experiments, and requested the assistance of Mr. Dollond, who prepared the instrument for him, which he most readily granted, by sending one of his principal men to adjust the instrument, and render every possible assistance; but it was all to no purpose. Thus eight or ten days were lost in anxiety and perplexity; all who saw the instrument approved of the principle, but no one could account for the discrepancies in the observations. Continued perseverance at length led Mr. Clark to think, that the differences arose from the instrument being fixed upon a wooden frame, which being subject to the effects of expansion and contraction from the variations of temperature, the instrument must also be affected thereby. No sooner had this occurred to him, than he ordered a brick pillar to be raised, and capped with stone, independent of the wood work of the observatory. No time was lost in raising it, and the instrument was fixed and adjusted, and the line fresh ranged. Observations were then made, morning and evening, for some days together, and the results were perfectly satisfactory.

The instrument being finally adjusted, the distances of the working shafts were fixed upon and ranged by it; and, when sunk to their proper level, on the outer edge of each shaft were fixed two wooden frames, for receiving two lines with heavy cast-iron plumb weights, which were lowered to the requisite depth, and immersed in water to prevent their motion as much as possible. When the lines were fixed in any one shaft, the instrument was taken down and fixed in the shaft, and the vertical hair adjusted to intersect the suspended lines, by which means the heading was driven from shaft to shaft, and a direct line obtained. The advantage of this mode of proceeding, by first driving a heading, must be obvious from the facility it afforded in the execution of the work, as well as exposing to view the nature of the soil. The shape of the heading partook of the finished form of the apex of the arch. The work was thus conducted by working from both ends of the Tunnel, as well as from nine shafts, up which the excavated matter was raised to the surface by horse whins.

It was expected that the chalk formation would be favourable for a Tunnel, but from its treacherous nature it proved to be otherwise, although parts were found to be very dense, requiring the aid of gunpowder to separate them. This occurred under the greatest elevations, as though pressure had made the strata below more solid; for in the valley the chalk was of a very loose description, and a considerable quantity of brick arching was necessary to protect the roof, the arching springing in some places from the bottom of the Tunnel, in others above the level of the towing path, as shown in section plate LXXXVI, in proportion to the nature of the ground; and, to reduce the expense of the brickwork as much as possible, side arches were introduced with considerable advantage, as no extra expense was allowed for

* A full description of a Transit Instrument, the method of adjusting it for observation, and of using it, is given in Simms's Treatise on Mathematical Instruments employed in Surveying, Levelling, and Astronomy, published by J. Weale.

their introduction. The thickness of the brickwork in the arching varied in proportion to the solidity of the chalk, and this was very uncertain, being in some places intersected with very loose chalk, mixed with veins of earth. Wherever this occurred, the quantity of timber required for securing it was considerable, so much so as to leave scarcely room for the miners to work; and, in many instances, the pressure on the upright timbers was so great as to crush them, although of the best yellow pine spars, of nine inches diameter, that could be procured. In these parts of the work the arching from the springing was eighteen inches in thickness, and reduced at the apex to fourteen inches. Whatever space remained over the arches was, in all cases, carefully built up with chalk and lime mortar, as the arching proceeded, so as to render the pressure as equable as possible. The chalk was so loose in some parts of the work as to render the progress not only very slow, but exceedingly dangerous, and side headings were in such cases adopted, and the walls carried up within them to the springing line. The spaces in front, and at the back of the walls up to the sides of the headings, were carefully built up with chalk and mortar, until the arching was turned and made solid over it.

The ground at the Friendsbury entrance was composed of nodules of chalk and flints, intermixed with loose earth of the most friable description, which was readily moved by the rain. An attempt was made to secure this entrance by commencing from the outside face: but this mode not succeeding, Mr. Clark determined to commence from within, at some considerable distance, by means of side headings; and by this mode the entrance was secured, although with great difficulty.

It was found in all cases necessary to secure a portion of the roof, right and left of the working shafts, with brickwork; which no doubt prevented the occurrence of many accidents: a few, however, could not be avoided. Notwithstanding every possible precaution was taken to ascertain the soundness of the chalk during the progress of the work, and no expense was spared for timber for securing the workmen from injury, yet no human foresight could anticipate the probability of a fall before it took place. Some serious accidents occurred, both from the fool-hardiness of the miners, and from the wanton and wicked acts of others, in cutting the whin ropes nearly through, by which several were severely hurt, and one killed. In works of such magnitude it is scarcely possible to arrive at completion without occasional accidents.

It was originally intended that the Tunnel should have a passing place arched with brick, 200 feet long and 50 feet wide, in the middle of its length; but, in consequence of the great additional expense which would be incurred in its execution, the plan was abandoned by the Committee. In the course of a short time, however, it was found absolutely necessary, for the purposes of traffick, that there should be some place for the barges to pass each other, near the centre of the Tunnel, and an open cut was made in the valley, there being at that point the least depth of cutting. (Plate XC.)

It was found, during the progress of cutting the Tunnel, that the wells in the neighbourhood, the bottoms of which were above the bottom of the Tunnel, were deprived of water, although some were three quarters of a mile distant. They were immediately lowered, and the supply was restored, but, on the admission of the water into the Canal from the Medway, which is salt, all the wells were affected more or less. The Committee supplied the complainants by water carriers for a considerable time; but, as this was attended with much inconvenience and expense, juries were impanelled, and damages assessed, which the Company paid.

The Lock at Gravesend, and the Canal up to Higham, were completed before Mr. Clark's appointment as engineer to the Company, but the bridges and all other works were constructed under his direction.

The Canal as executed was not of sufficient depth to hold the necessary quantity of water between spring tides to supply the loss occasioned by lockage-water and evaporation, nor could it be deepened without a vast expense and loss of trade. These considerations led to the erection of a steam-engine to make good the deficiency.

The transit instrument, which was first employed by Mr. Clark in the construction of Tunnels, and shown in Plate LXXXV, is now very generally employed in setting out the direct line, and establishing the working shafts of such Tunnels as are of considerable extent. Mr. Stephenson has employed it with great success on the Birmingham Railway, and Mr. Brunel in like manner on the Great Western, as well as in setting out the direction of that great work, the Thames Tunnel. It appears that a transit instrument is indispensible to the correct execution of such works.

GRAND TRUNK CANAL.

HARECASTLE NEW TUNNEL, STAFFORDSHIRE.

Plate XCII.

The old Tunnel on the Grand Trunk Canal, at Harecastle, in Staffordshire, was executed by the celebrated Brindley, and was built with a semicircular brick arch, springing from the water line of the Canal: it is but ten feet in diameter, and consequently without a towing-path.

The increase of trade on this Canal, together with the delay occasioned from the want of a towing-path, made it expedient to form a new Tunnel alongside the old one, and this was carried into execution by Mr. James Potter, from the designs, and under the superintendence, of the late eminent Mr. Telford.

Sections of the new Tunnel, showing its dimensions, and the radii with which the curves forming it were struck, together with the details of the towing-path, and the construction of the centering, are given in Plate XCII. These have been carefully reduced from the original working drawings, which were obligingly lent for the purpose by Mr. Potter, to whom we are also indebted for the following particulars.

The geological character of the ground through which it was necessary to excavate for the formation of the Tunnel, was quicksand, clay, marl, iron-stone, coal, coal measures, rock, &c.; the Tunnel was consequently bricked throughout. Its exact length is 2926½ yards. For its construction fifteen working shafts were sunk, each nine feet in diameter, and their depths varying with the undulating surface of the ground, the deepest being sixty-four yards: none of them were bricked to the whole depth. The whole of these shafts were afterwards filled up.

The whole of the towing-path is composed of stone, except the paving, which is of hard and vitrified bricks, set in barrow-lime. The handrail is of wrought iron, riveted in lengths of eighteen feet.

All the bricks for the Tunnel were made from marl or clay, which was first passed through rollers, and afterwards well blended with water in a mill, upon a principle similar to the loam mills used in large iron foundries.

The whole of the mortar was made from barrow-lime, burnt upon the ground, and worked in mills upon the same construction as those introduced by the late Mr. Rennie at the Liverpool Docks.

The clay and mortar mills were worked by four steam-engines.

The whole cost of the Tunnel *per lineal yard*, including shafts, headings, cross-headings to the old Tunnel to carry off the water from the new one, towing-path, entrances, two turn-over bridges, open

cuttings at the ends, and a railway or tram-road over the hill, and to the various brick-yards, to convey the materials to the several shafts (and which was about six miles and a half long), and every other expense, was £38. 10*s*.

The old Tunnel is kept open and in use; all boats proceeding northwards pass through the new Tunnel, and those passing southwards through the old Tunnel, through which they are propelled by leggars.

The first turf for the open cutting at the south entrance was cut on the 22d of March, 1824, and the Tunnel was opened to the trade on the 30th of April, 1827.

The first brick for the Tunnel was laid on the 21st of February, 1825, and the last brick (not taking the towing-path into consideration) was laid on the 25th of November, 1826; which interval contains 550 working days; and, supposing that every one of these days had been fully devoted to the works (which is not very likely), there probably has been no Tunnel of the same length which has ever been constructed in so short a time.

In Phillips' "General History of Inland Navigation," fourth edition, page 430, there is a note relating to the old Tunnel at Harecastle, of which the following is a copy:—

"I was at the digging and vaulting the first Tunnel that ever was performed in this country, invented by my old master, Mr. Brindley, through Harecastle, in Staffordshire, in 1776, and which cost only £3. 10*s*. 8*d*. per yard, and that was thought a great sum of money.

"The Tunnel at Sapperton, to join the Thames and the Severn, through two miles of solid rock, cost only about eight guineas per yard." This Tunnel was opened for trade on the 20th of April, 1789.

MONTGOMERY CANAL.

DESCRIPTION OF LOCKS ERECTED ON THE MONTGOMERYSHIRE CANAL.

Plate XCIII.

COMMUNICATED BY G. W. BUCK, ESQ.

In the following account it is not intended to enter into a description of the nature and properties of locks, which are universally understood, but only of those particulars in which, I believe, these locks differ from those erected by other Engineers; stating the reasons for each particular variation.

THE GATES.

In the construction of the gates cast-iron has been adopted instead of timber, in consequence of its greater durability; they are cast in one piece, the bars are on the upper side of the gate, and the plate of metal on the lower, the reverse of timber gates, but obviously preferable in cast-iron, in consequence of its superior strength when put into this form. The two gates, when shut, form a segment of a circle, the chord of which, measured from centre to centre of the heel-post of the gates, is eight feet, and the versed sine one foot four inches, or one-sixth of the span.

This proportion is much flatter than that usually adopted, but, in consequence of the narrowness of the lock, the radius of the curve is only six feet eight inches, and it is attended with the practical advantage of making the gate smaller, lighter and stronger, as well as of increasing the pressure of the heel-post against the hollow quoin, which is desirable in small gates to render them water-tight.

The gates are made water-tight at the mitre-posts, by being rubbed dry, the one upon the other.

This operation is performed by one gate being fixed in the ground with the mitre-post in a horizontal position, and the other placed thereon in the same relative position which they have when fixed in the lock; the upper one is then moved backwards and forwards, through a space of about five inches, by a crank, until a perfect joint is obtained by the attrition between the two surfaces.

The gates clap against a sill of oak nine inches by six inches, the top of which is flush with the masonry. This sill is fastened by bolts which screw into cast-iron dovetailed boxes, sunk into the stone below the sill; the heads of the bolts are round and flush, the joint between the stone and wood is made water-tight with flannel and white lead. The sills extend no further than shown in the Plan, and can be renewed at any time without disturbing the masonry.

The joint between the heel-post and hollow quoin is made water-tight, by the gate being keyed up moderately tight, and then worked backwards and forwards for a few hours, sand and water being made to flow into the joints. Gates thus fitted are made perfectly water-tight.

The paddles of the lower gates are of the usual simple form, of two feet square; but in order to prevent their being broken by being dropped in shutting them, they are balanced by a counter weight, as shown in the upper right hand figure.

In narrow Canals the paddles of both the upper and lower gates are usually kept open by an iron pin being inserted between the teeth of the rack and pinion by which they are raised, and when the paddle is required to be shut, the pin is withdrawn, and the paddle falls down by its own weight. Now, although this rude method will work a few years where wood is employed, it is quite inadmissible where cast-iron is made use of; consequently the counter weight is indispensable, and its introduction is attended with the additional advantage of diminishing the force required for raising the paddle.

The bottom of the heel-post rests on a pivot, which is let into the masonry, and shown at B B in the figure last referred to. The pivot and corresponding cup in the heel-post are chilled: the heel-post at the top is secured by a collar and anchor, made much larger and stronger than is usual for gates of these small dimensions, and for the following reason:—the boatmen who are employed upon Canals, having no other object in view than the arrival at their journey's end in the smallest time possible, will seldom take the trouble to shut the lower gates of the lock by hand, but usually open the upper paddles, and permit the current to close the lower gates, which is done with great violence; the momentum of the gate is suddenly destroyed, partly by the sill at the bottom, and partly by the collar and its anchor at the top; and the following effects are observable:—the stone to which the anchor is fixed is forced from its bed, and partially drawn over the face of the wall; sometimes the anchor is broken, and sometimes the balance pole, as the lever is called. Without doubt the lever derived this appellation from its having been made of a heavy piece of oak timber, with its but end outwards, designed to act as a weight to counterbalance that of the gate; and to render it more effectual in this respect, a box filled with stones has frequently been added to its extremity. Now a moment's consideration will be sufficient to perceive that the momentum of the balance pole is highly injurious, and that if it were entirely dispensed with, as is the case in ship locks, the evils just pointed out would not happen; but if it be convenient, as it undoubtedly is, to retain this beam, as a lever by which to open and shut the gates of small locks, it ought to be made as light as possible, particularly at the extremity furthest from the centre of motion, where it has been customary to make it heaviest. That it is unnecessary as a balance may be shown as follows: the weight of one of these gates is about two tons and a half, and the horizontal strain which this weight exerts upon the anchor is only about seven hundred weight, or no more than about one tenth of the force necessary to disturb the anchor stone, independently of the contiguous masonry, to which it is secured by joggles.

For these reasons the *balance* poles are dispensed with, and the levers by which the gates are opened consist of cast-iron pipes, three quarters of an inch thick, eight inches external diameter at the heel of the gate, and four inches at the other end, with a handle of wood, C, driven into them.

The upper pannel, A, of the same figure is filled with a block of elm to receive the blows of the boats, and a plank of elm five inches thick is fixed on the top, the edge of which is flush with the block A, and serves the double purpose of a bumping piece and a foot bridge.

The references given have been to the figures of the lower gates only, but they are equally applicable to the upper.

BUMPING APPARATUS.

For the protection of the masonry and sills of the head from the destructive effects of the blows given by boats entering from the lower level, a double thickness of four inch elm plank is usually suspended by chains from the sills against the face of the wall of the forebay at A. (see plan.) The defect of this method is, that the wall at A still receives the whole momentum of the boats, and the bumping planks only spread the blow over a larger surface and prevent the *immediate* destruction of the brickwork or masonry; but in a few years the masonry is shattered, the materials fall out of their places from behind the bumping pieces into the chamber, the head of the lock becomes leaky, and eventually it is necessary to rebuild it.

Instead of the above I have practised the following :—

The bumping pieces, B, B, shown in the plan and longitudinal section, made as usual, are bolted to two transverse pieces of oak, which are loosely bolted at their ends to four cast-iron dogs, E, E, fig. 2, built into the side walls; the ends of these castings project six inches into the chamber, and are retained in their places by wrought iron bolts, G, G, two inches square and about sixteen feet long, one end of each being keyed into the castings near the face of the chamber wall, and the other end into a square cast-iron plate, D, placed in the centre, of the thickness of the chamber wall. The bumping piece, B, is of such dimensions, that the lower end of it descends about six inches below the surface of the level of the water in the lower pound, and the upper end is level with the clap sill F of the upper gate. By this arrangement the blow of the boat is not received at all by the wall at A, but is transmitted through the oak beams C, C, castings E, E, bolts G, G, and plates D, D, to the chamber wall D, D, which is immoveable in that direction. The ends of the dogs, E, to which the oak beams are loosely attached, are slightly curved, to permit of the beams bending with the blow of the boat, and these beams act as spring fenders: thus the injury to the lock arising from the momentum of the boat is completely prevented, and that done to the boat is very much diminished. Fenders of this description were erected by me in the year 1819, and have answered perfectly, not the slightest injury having been sustained by the masonry, although several bumping pieces, B, have been worn out since that date.

FENDERS.

The wing walls at the head and tail of the lock are defended by detached guards or fenders of timber, H, H, H, H, plan and longitudinal section, each about 35 feet long; they are supported by posts I, I, framed and braced into sills K, K, which are sunk about 4 feet below the bottom of the Canal. They are also further supported by posts firmly fixed near their other extremities, which are laid into the Canal bank. The distance between the inner ends of the fenders is equal to the width between the hollow quoins, and they consequently direct the boat with precision into the lock, and protect the walls from any violent concussion; also, in consequence of their elasticity, they endure many years, and are not liable to be out of order.

MODE OF FILLING.

The usual mode of filling small locks is by means of a vertical paddle on each side, which admits the water to flow into a square stone conduit constructed in the midst of the masonry of the head, and the water issuing from both conduits is brought into one, in the centre of the forebay. The objections to this construction are the following :—

A powerful stream of water is admitted into the heart of the work, when it is subjected to several sudden changes of direction, by which the velocity of the influx is much diminished, and the force thus lost is expended in destroying the stability of the walls; the water finds its way through the joints of the conduit or trunk (as it is generally called), and leaks through nearly all the neighbouring parts.

The paddles, when lifted by a rack and pinion, and allowed to shut by falling, are soon destroyed, as was before remarked when describing those for the lower gates.

The construction which has been substituted is as follows:—only one paddle is used instead of two, first, because it is less expensive; second, because less time is required to open one than two; and third, because this canal had a towing-path on one side only, and for that reason the crab for opening it was placed on the opposite side, to be out of the way of the boat-lines.

In order to render it impossible to drop the paddle, its position is horizontal; to effectually exclude the water from the masonry, a cast-iron pipe is adopted for the conduit; that the masonry might be interfered with as little as possible, and to shorten the length of the pipe, it is placed as shown in the plan and section.

An inspection of the plate will be sufficient, with very few words of description, to make any one fully understand the means of opening the paddle. The pipe is two feet diameter, the end of the pipe to which the paddle or valve is attached is gradually altered in shape and dimensions, from two feet diameter to two feet square; the valve is pushed and pulled on and off by a wrought-iron connecting rod M. When the valve is opening, the connecting rod acts upon it at A, and when shutting, at B. It rests on a boss or segment at C, to allow of the vibration of the rod in a circular arc at the other extremity; the other end of the connecting rod is attached to a perpendicular cast iron beam, A, A, (see the upper left hand figure), hung on a shaft at C. The upper end of the beam consists of a segmental rack, which works into a pinion A, and this pinion is fixed upon a small shaft driven by a wheel, pinion, and winch. By means of this crab, the valve or paddle is easily opened by the boys who generally drive the boat horses. A small air pipe is inserted immediately below the paddle, and its upper end terminates under a small iron dome with lateral openings in it at *f*. (see the upper left hand figure). The use of this air pipe is to permit the water which is in the pipe below the valve to sink to the level of the water in the lock when empty, so that the resistance to be overcome in opening the valve never exceeds that which is due to the height of water above the valve, and is thereby independent of the depth of the lock.

TIME OF FILLING.

It will be interesting to show the difference between the actual time of filling, and that obtained by computation:—

Let $g = 32\frac{1}{6}$ feet, the velocity generated in a second by gravity,
A = area of the lock,
a = do. of the pipe,
h = the whole lift of the lock,
x = any variable part of do.
t = the time of filling in seconds,
v = the velocity of the influx per second,

Then $v = \sqrt{2gx}$, and the ascending velocity of the surface of the water in the lock will be inversely as the area of the lock, and directly as the area of the pipe by which it is filled, or as $\frac{a}{A}$: therefore $\frac{a}{A}\sqrt{2gx}$ = the velocity with which the water rises in the lock; and by the formula for variable forces $dt = \frac{dx}{\frac{a}{A}\sqrt{2gx}} = \frac{Adx}{a\sqrt{2gx}}$ the integral of which, or $t = \int\frac{Adx}{\sqrt{2gx}} = \frac{2A}{a}\sqrt{\frac{x}{2g}}$, and when x becomes h, (calling g = 32 feet,) the expression becomes $t = \frac{A}{4a}\sqrt{h}$, the time of filling in seconds.

The following Table exhibits the actual time of filling, as observed at six locks on the Montgomeryshire Canal, which have been fitted up with paddles of this construction.

Name of Lock.	Lift		Actual time of filling		Computed time of filling		Difference of the times.	
	Feet.	In.	Min.	Sec.	Min.	Sec.	Min.	Sec.
Cabin Lock . .	8	9	2	10	2	28	0	18
Crowther's Hall . .	9	1	2	20	2	30	0	10
Pool Quay . .	9	1	2	30	2	30	0	0
Pool Town .	5	7½	1	43	1	58	0	15
Belan Upper .	7	0	2	10	2	12	0	2
Belan Lower .	5	6	1	40	1	57	0	17

The mean length of the above locks is eighty-one feet, and the mean width seven feet nine inches.

In the above it will be remarked, that in one instance the observed and computed times are identical; but what is more remarkable is the fact, that in all the others the actual time of filling is less, by a few seconds, than the computed time. In most cases the velocity of water passing through a pipe is less than that assigned by pure theory, friction being neglected; indeed, when the length is considerable, it is always so; but in this case the length of the pipe is inconsiderable with respect to its diameter, for instance, in the lock whose lift is nine feet one inch, the length of the axis of the pipe is twenty feet two inches, the diameter being two feet. Now the theory supposes, that the velocity of influx at each instant is always precisely that which is due to the difference of level of the surface of the water within and without the lock, and that the velocity vanishes when the two surfaces coincide. But the influx *does not cease* when the two surfaces coincide, because the momentum of the column of water contained in the pipe is such, that the stream continues to flow into the lock, actually overfilling it, when a contrary current sets out of the lock, and thereby opens the upper gates. It is therefore obvious that the velocity of the stream during the latter part of the influx is greater than that which is due to the difference of level, and that it partakes of the superior velocity previously impressed, and does not vanish when $h = 0$: hence it follows, that the time of filling is a little less than the computed time.

GLOUCESTER AND BERKELEY CANAL.

PLATE XCIV.

SPECIFICATION OF WORKS.

Gloucester and Berkeley Canal.—Specification of the Works to be executed in completing and making navigable the Canal from Gloucester to the Entrance Gates of the Basin of the said Canal next adjoining the River Severn, near a place called Sharpness Point.

The old part of the Canal, from the locks at Gloucester to the south side of Hardwick Church-Lane Bridge, a distance of five miles and eighty-two yards, must be cleaned up, and all the mud, dirt, stanks, or dams, and other obstructions lying below the level of the top water of the Canal removed, and the Canal deepened, upon the old slopes, to the depth of eighteen feet below the level of the weir at Witminster, as marked upon the section thereof annexed to these presents; but as the section here referred to was taken while the water was in the Canal, a new section to be made jointly by the Contractor and the Resident Engineer for the time being of the said Company, where the water is taken off the Canal, and to be signed by them respectively; and the difference in quantity, if any, to be paid for, or deducted from, at the rate of one shilling per cube yard. Also the several following slips, beginning at the south end, viz. One on the north side of Hardwick Church-Lane Bridge, on the towing-path side, near a large gully (occasioned by a former slip), sixty-six yards in length, or thereabouts; One at the gully, twenty-nine yards in length; One near the south side of Hardwick Bridge, sixty-six yards in length; One near ditto, twenty-two yards in length; One ditto, about three hundred yards before coming to Slimbridge, in the turn, seventy-two yards in length; One on the off side, and opposite to the last-mentioned slip, forty-four yards in length; One near Holburn's Green culvert, fifteen yards in length; One by the culvert, twenty-two yards in length; One on the off side, between Hempstead Bridge and Lanthony Bridge, twenty-two yards in length. These slips measuring altogether 4383 cube yards. Should any more slips come in than as above described during the execution of the said works, they must also be taken out, and a price or rate of one shilling per cube yard paid for every such yard of earth. The mud, or dirt, arising out of this work, may, in part, be laid out on the bank, between the fence and the slopes of the Canal, but only in such places where it can be done with convenience and safety to the works, and the situation approved of by the resident engineer. There are several pieces of land belonging to the Canal Company adjacent to the works; and the said Contractor is to be allowed to take the use of the said pieces of land for laying on the spoil, but the dirt must be spread and levelled in a workmanlike manner: for such portion as may be boated away, the ground or place for holding the same will be marked out as convenient to the work as circumstances will allow, namely, not exceeding three quarters of a mile from the end of the old cutting, on the line of the Canal towards Frampton, but to be laid out, either on the east or west sides of the Canal, as the resident engineer may direct, not exceeding three chains breadth on each side of the Canal, in the foregoing length of five miles and eighty-two yards. There are five finished swing Bridges, namely, Lanthony, Hempstead, Slim, Rea, and Hardwick; these Bridges must be examined, and such repairs given in wood and iron work as may be found necessary; the circular plates and balls upon which the bridges swing must be cleaned, the balances adjusted, and the bridges put into a moveable and workable condition, as far as the proposed cleaning and repairing in wood and iron will make them so; but there is to be no alterations in the plan and construction of the Bridges.

At Holburn Green the culvert through the bank on the off side of the Canal is washed down, and is to be restored, or an inlet erected in lieu thereof, upon such plan as will be made out by the resident engineer; the culvert at Hardwick Church Bridge is to be lengthened five yards, and an inlet laid of five yards at Hardwick Bridge.

The banks, from the end of the old work, to the Cambridge arm, are to be raised in every part where they are found deficient, up to a level with those where the towing path has been completed and

gravelled, and the side puddles completed along with them. Between Park-end Bridge and the junction with the Stroud Canal a considerable quantity of work is necessary, both on the east and west sides of the Canal; the stuff for making up these banks to a level with the completed parts is to be boated from the spoil already laid out, and from a benching to be taken off the towing-path, between the Stroud junction and Frampton Bridge. The embankments to be made complete at the Stroud Junction; such parts of the towing-path as remain to be done and left unfinished are to be made out in the same way as those parts now completed, and the gravel taken from the back of the banks in the sand field.

The mason work of the Bridges, to wit, Hardwick Church-Lane Bridge, Parkend, Pegthorn, Sandfield, and Frampton Splat Bridge, is to be completed from the state they are now in, with a wing wall added to Pegthorn Bridge and Hardwick Bridge, of the same dimensions and quality of work as described in the plan for the new Bridges to be built on the Canal below the Cambridge Arm; the back of the abutments are to be opened, and a pier put in upon a solid and firm foundation, and carried up and finished on the top with ashlar stones, to receive the swing Bridges, as described in the specification for the new Bridges; the wood work and iron work is to be constructed and completed like those Bridges to be built below the Cambridge Arm, and with reference to the same plan and specification; the approaches to be banked up, and the roads made good over them.

CAMBRIDGE ARM.

This Arm extends 1835 yards from the line of the Canal, as shewn by the plan and section thereof hereunto annexed; there is a considerable quantity of dirt and sediment in the bottom, all the way to the head of the wharf, which is to be cleaned out upon the present slopes of the work to the depth of five feet below the level of the top water of the Canal, as represented in the said section, and the stuff thrown to the bank on the south side. All deficiencies in the bank, on the towing-path side, are to be made up, and a bend or turn improved as marked on the field plan hereunto annexed, and the bank levelled and dressed down in a workmanlike manner; the top of the bank (for the towing-path) is to be gravelled six feet wide and six inches deep; from the Bridge the towing-path is on the north side, and the gravelling must be continued in the same manner to the wharf.

The Bridge is in part built, and the abutment walls are to be carried up nine feet above the level of the top water, and then laid over with five half balks, and crossed (for the roadway) with elm planks two and a half inches thick, and protected by a hand-rail three feet high. There are to be four wing walls, twelve feet long and three feet thick, to form the approach to the Bridge, built with rubble stone in a workmanlike manner; the road over the Bridge is to be made under the direction of the resident engineer of the Company, and to his satisfaction.

The wharf wall, one hundred yards long, to be coped with good ashlar stones, not less than three feet long in the face, two feet on the bed, and twelve inches thick, laid in a good mortar.

EARTHWORK FROM THE CAMBRIDGE ARM TO SHARPNESS POINT

This length of the Canal is five miles, one furlong, and one hundred and forty yards, as per section hereunto annexed, and to be of the following dimensions, conformable to the longitudinal and cross sections hereunto annexed; that is to say, the depth of the water to be eighteen feet below the level of the weir at Witminster on the Stroud Canal; the bottom to be thirteen feet wide (except that part below Purton to Sharpness Point as marked upon the plan, and described in another part of the specification); the inside slopes, up to the thirteen feet in height, to be twenty-one inches horizontal to twelve inches perpendicular, and from thence to the top bank level, four feet above the surface of the water, two horizontal to one perpendicular. At the height of thirteen feet from the bottom level a benching is to be made on each side of the Canal of four feet wide; therefore the width of the Canal, at the water's surface, will be eighty-six feet six inches, and at the top bank

level, one hundred and two feet six inches. All the embankments to be twelve feet wide on the top, and the outside slopes the same as on the upper part of the inside, to wit, two to one.

In cutting through the hill at Purton, a benching to be made on each side, twelve feet in width at the top bank level on the same slope as below; and the benching of four feet at the height of thirteen feet from the bottom will be dispensed with through this part.

The spoil to be laid out on the north side, and properly levelled and soiled, after first stripping the soil from under the seat of the bank. In all other places where spoil banks are made to be finished in the same way.

That part of the Canal below Purton as described upon the plan hereunto annexed, No. 1, and contained between A and B, to be finished according to the dimensions and slopes which have hitherto been followed in respect to this part of the Canal. All the mud, and every other deposition brought in by the repeated flowings of the tide, must be thrown out in the tideway on the back side of the works.

All sand and gravel found in completing the wide place must be reserved for the use of the works forward from B to the locks between the sea wall and the cliffs; the bottom width must not be less than thirty feet; and, on approaching the locks, not less than fifty feet, commencing one hundred and eighty yards from the head of the locks, and as marked upon said plan No. 1; but, if the resident engineer finds it necessary that rock be cut out for this purpose, it is to be paid for at the rate of one shilling and sixpence per cube yard extra to the contract price. In passing Dinmore Hill the ground is below the top water level of the Canal, and the bank is to be made two feet above the level upon the solid ground, and a good side puddle made therein, and to be ranged out so as to leave room for the company to complete the works at a future time, fifty feet wide in the bottom at least. The slopes on the wall side to be eighteen inches to twelve inches; and, if the resident engineer requires any thing to be done on the cliff side beyond the width of seventy-six feet from the inside of the parapet wall, to be paid for at the rate of one shilling and sixpence per cube yard.

The bank width along the sea wall to the locks is to be made and left sixteen feet from the inside of the parapet, as per transverse section of said work hereunto annexed.

The Basin at the point to be excavated and completed to the extent as shewn by the plan here annexed, with the off side or that next to the rocks cut down perpendicular to the bottom level of the work. All the rock and rubbish arising out of the work in passing by the cliffs, and also from the Basin, to be laid out in the tideway on the north side of the long sea wall, as shall be directed by the resident engineer, so as not to occasion any obstruction to the entrance to the Basin, or to the prejudice of any other part.

Where side puddling is necessary, the gutters to be cut three feet below the surface of the ground, or to such further depth as may be proper for a foundation; these puddles to be four feet thick, and carried up perpendicularly to one foot above the water's surface, as shewn on the section.

The puddling along the sea-wall to be carried forward in courses as the banking and masons' work advances.

The towing-path is to be covered, nine feet wide, with small broken stones (none to exceed four ounces in weight) seven inches thick, and covered with gravel three inches thick, the stones being raked therefrom in finishing off the work. The tow-path in the fields to be fenced off with oak posts and double railing of such quality as is generally used in fencing, the posts not to be shorter than six feet, and the rails not more than nine feet long, put in with mortices and tenons. A quick border to be made with good soil, not less than nine three-year-old sets planted in a yard.

The line of fencing to be marked out by the Resident Engineer.

All the cross fences in the line of the cutting to be grubbed up and cleared to the outside of the banks, previous to forming thereon. A sufficient quantity of soil to be taken from the surface of the ground that is to be cut for the Canal, or covered with embankment, or spoil, and reserved for the purpose of resoiling the banks, not less than six inches thick, and spoil banks nine inches deep. In all cases of spoil banks, they are to be laid out in an uniform breadth, brought to a fair and regular surface on the top, and finished with a slope of four to one, or in such other way as may be more suitable to the ground on which it is deposited.

The foundations of the bridges are to be dug, and the approaches made, in a proper manner, and finished to the satisfaction of the Resident Engineer; the foundations are to be cut of all the stop gates, culverts, waste weirs, trunks, and other works herein specified to be done.

The temporary fencing is to be provided and kept in repair during the execution of the works.

Whatever stones, sand, and gravel, found in digging and opening the cut, is not to be sold or taken from the work, but may, where suitable, be used in the works: all such materials as shall not be used are to be laid out separately from the other materials used in constructing the works, in such places as may be directed by the Resident Engineer, but in no case to be buried in the banks, or in any other part of the works.

A back drain, on the off side of the Canal, is to be cut to join a drough to the royal drough, of six yards mean width, and about ten feet deep. This cut is on the south side of the royal drough.

The forming and making the junction with the Stroud water navigation will consist in finishing one lock, four pair of stop gates, the alteration in the bridges, and completing the banks to their proper level, and several other things connected with the execution of the work to be performed in conjunction with the Stroud Company.

SEA WALLS, LOCKS, CULVERTS, &c.

Sea Wall.—The building being considerably advanced, before any new work be placed thereon, the surface, or upper bed of the work, is to be cleaned and scraped over with a trowel or some other tool, and the loose stones and mortar taken up and bedded again, that the new work may be united with the former work in a proper manner. In parts and places where the foundations are not in, the work is to be sunk to the solid rock, and founded thereon, and brought up in the manner expressed in the drawing thereof hereunto annexed, but if the foundation be bad at the level shewn in the said plan, the work must be founded accordingly.

The face of the wall to be freestone of a durable quality, taken from the Forest of Dean, or from any other place, provided the quality be approved of by the Resident Engineer. The ashlars to be laid on their beds, and prepared with a chisel draught round their face, and the other part left rough.

The stretchers not to be less than ten inches, nor more than eighteen inches in height, and to be laid with headers every eight feet; the stretchers to average eighteen inches in that parts of the wall extending from the north end to the upper gates of the locks, but from thence, in the other parts of the wall, to average two feet on the bed, but no stone to be less than eighteen inches, and not shorter on the face than two feet; the headers to be from three to five feet long in their beds, so as not to be less than four feet on an average, and not less than two feet on the face, with the beds picked fair off for the whole length of the stone.

This wall to be five feet wide on the top, and seventeen feet at the base, at the level of the lower sills of the locks, and carried up with a curved batter of twelve feet, to two feet above the top water

level of the Canal, and finished with a plinth (for the basement course of the parapet wall) nine inches in height, two feet in breadth, and set with a projection of one inch on the Severn side.

The parapet wall, from the north end down to the head of the locks, to be four feet six inches high, and eighteen inches thick, to be built with good flat hammer-dressed stones, set without any pinnings, and coped with ashlar stones twelve inches thick, rounded off on the top, as in the drawing thereof hereunto annexed. From the head of the locks, to the centre of the pier head, the thickness of the parapet to be increased to two feet, and built in courses, with ashlar stones properly dressed, and coped like the former part of the wall; from this place, round the head of the pier, and up to the gates of the basin, the wall to be reduced to two feet in height, with the top stones rounded off like the other part of the wall as above described.

The parapet wall, on the south end of the basin to the centre of the pier head, to be finished like the wall from the head of the locks downwards, and on to the gates of the basin as first described. The inside walls of the basin to be thirty-eight feet high from the bottom level; eight feet thick at the base, and four feet at the top, carried on a curved batter of four feet in the whole height, as described in the transverse sections of the walls hereunto annexed (Plate XCIV.); and in other respects composed of ashlar stones, header and stretcher, like those for the sea wall, except that it is to be picked between the chisel draughts.

The coping stones to be eighteen inches thick, not less than three feet long in the beds, and not less than two feet in the face, with the joint quite square throughout, and the top arris rounded off.

The counterforts to the foregoing described walls to be five feet wide, four feet long, and fifteen asunder, to be tied or bonded into the walls, and have long scabbled stones at every four feet in height in a workmanlike manner. The counterforts in that part of the wall above the locks to finish at the level of the water's surface as in the drawing.

The puddles, on the back of the walls, to be sunk three feet for the foundations below the level of the lower sills of the locks, and carried up, five feet wide, in regular courses with the mason's work, to the under bed of the coping stone, and the space from thence to be made up with fine clean gravel.

LOCKS.

The ship-lock and barge-lock are united by placing a pair of gates in the chamber, as in the plan thereof hereunto annexed. The ship-lock is 163 feet long, from the centre of the lower gates to the centre of the upper gates; twenty-nine feet six inches wide at the springing of the inverted arch; thirty-six feet at the level of the upper sills; and thirty-eight feet six inches at the top of the walls, as figured on the plan. The barge-lock is 115 feet long from gate to gate.

The trow-lock is eighty-one feet six inches long, from the centre of the lower gates to the centre of the upper gates; thirteen feet six inches wide at the springing of the inverted arch; eighteen feet at the level of the upper sills; and nineteen feet six inches at the top of the walls, as marked on the plan thereof hereunto annexed.

The locks will be founded upon rock, which, at the proper level, is to be cut to fit the curve of the inverted arches, and the bottom of the side walls, as shewn by the plan, and if any deficiencies arise in taking it out, they must be made carefully up with good mortar.

The bottom of the ship-lock to be made as represented on the plan thereof hereunto annexed; an inverted arch of stones, two feet deep in the centre, and increasing regularly to five feet at the springing, but the courses, near the side walls, may be built of two stones in length, except in such parts as the Resident Engineer may otherwise direct, each course to be laid in one thickness throughout, the beds

being truly wrought to the radius of the arch, and the end joints squared the full depths of the stones. All the stones must be of such length as to overlap or break joint one foot.

At the lower end of this inverted arch, there must be a beech or elm sill one foot square, extending three feet under the side walls, with three-inch grooved sheeting piles, five feet long.

The inverted arch of the trow-lock is to be composed of stones eighteen inches deep in the centre, and two feet six inches on the sides, bedded and jointed similar to those in the arch of the ship-lock. The side walls are thirty-eight feet high from the level of the lower sills, and seven feet wide on the top, and of such other dimensions, with counterforts and pillars, as are described in the drawing thereof hereunto annexed.

These walls are to be built of stones of the same quality and dimensions as those described for the sea wall below the locks, namely, the stretchers to average two feet on the bed, and the dressing the same as for the inside walls of the basin. The ship-lock to have a batter on the face of four feet six inches, and the trow-lock one of three feet, as expressed by the transverse section thereof hereunto annexed. All the stones are to be laid at right angles to the face of the wall.

The walls are to be coped with stones eighteen inches deep, not less than three feet long on the beds, and not less than two feet on the face, with the upper arris rounded off; the stones to be closely jointed throughout, and to cover the whole of the counterforts or pillars on the back of the hollow quoins.

The forebay of the ship-lock to be fourteen feet thick on the top, and formed by two horizontal arches, one springing from the chamber walls and standing on the inverted arch below, and the other from the side walls above the gates; the first of these arches to be composed of well dressed ashlars, two feet on the bed, with headers intermixed and jointed in the direction of the radius of the circle; the other arch, as no part of it will be exposed, may be built with rough squared stones in corresponding courses with the former arch, but the joints are to be closely put together and firmly bedded.

The hearting or backing to be composed of the best flat bedded stones the quarries will produce, and laid solidly on their beds; hammer dressing is not required if a proper selection of the materials be attended to. The top bed of the last course of stones must be brought to a smooth and level surface to receive the platform of the gates.

At the head of the recess for the gates there is to be, as shewn in the plan thereof, a beech or elm sill of twelve inches square passing under the side walls, with a row of three inch grooved sheeting piles, each eight feet in length.

The forebay of the trow-lock to be nine feet thick on the top, formed by two horizontal arches, each being a segment of a circle, and composed and carried up with materials similar to those in the forebay above described.

The foundations of the lower gates are to be sunk into the rock six feet below the bottom level, and to pass under the side walls as shewn on the plan thereof, and a brick wall, or a wall of the best flat bedded stones, founded thereon, and brought up to the proper level to receive the platform of the gates, the upper courses being composed of ashlar stones eighteen inches thick.

The platform in the recess of the lower gates to be laid with well squared ashlars eighteen inches deep. The stones to be laid header and stretcher alternately, and of such dimensions as will break joint at least two feet in the head and bed of the stones.

The backing of the quoins to be of the same quality as that used in the forebay and the foundations of the gates.

The square quoins of the recess to be of large stones, headers and stretchers alternately, to be neatly joined on their heads, and the corners rounded off like the coping of the walls.

The sluices or conduits (for giving a communication from the upper level of the Canal to the chambers, and for supplying them with water) to be made from the upper recess walls, and pass through the side walls into the chambers; those for the ship-lock to be of a circular form, three feet diameter; and for the trow-lock, two feet square, and laid horizontally; the former to be built with good ashlar two feet in bed, and the latter eighteen inches in bed. The utmost care must be taken to make the work sound and as complete as possible.

The foundations for the gates of the basin, together with all the mason's work connected therewith, to be done in the same manner as described for the gates of the lock, and according to the plan and dimensions thereof hereunto annexed. The width between the gates forty feet; the well holes for the capstans to be built of rubble stones, and coped with ashlar two feet in the bed, and one foot deep, with proper coverings and stones to fix the machinery.

The rubble backing for all the mason's work to be of good forest stone, or from any other place, of a good quality and flat bedded. All the ashlars must be squared upon the end joints for at least nine inches from the face, laid on their beds in good mortar, and break joint not less than one foot.

The backing to be well bedded and filled with mortar.

The contractor is not to re-let.

The mortar must be made of clean sharp sand, and of Abathaw limestone, in the following proportions, that is to say, for works under water and exposed to the river Severn, in front, two measures of sand to one of lime; for backing all works under water, and exposed to water, three measures of good sand to one of lime; and, for all other backing, four measures of sand to one of lime; and the mortar required for the locks and outer gates of the basin, to be intimately mixed in a pug mill. The limestone is to be brought to the ground and burnt upon the site of the works; the contractor to have the use of any kilns now thereon, but he is to erect others if necessary.

All the puddling connected with the locks and sea wall to be carried up as the building advances.

WOOD WORK FOR THE LOCKS.

The whole of the timber for the gates, platforms, sills, sluices, &c. to be cut square and free from sap, according to the dimensions and of the quality specified in the bill of scantling hereunto annexed. To be framed, fitted up, and completed by such rabbets, mortices, and tenons, as may be approved of by the Resident Engineer, and completed and put out of hand in every respect in a workmanlike manner.

There must be six bridges or gangways on the locks and entrance gates; capstans and bars are to be provided for opening the gates.

IRON WORK.

All the iron work for the locks and the gates of the basin must be of the best quality, and provided by the contractor at the rate or rates of, namely,—for malleable iron in spikes and spike bolts, 22*s.* per cwt.; for ditto in screw bolts, &c. 30*s.* per cwt.; for fixed malleable iron, 1½*d.* per lb.; for cast iron to gates, capstans, and sluices, including patterns, 18*s.* per cwt.: for lead 26*s.* per cwt. Towards which work the sum of £500 is included in the contract price.

SCANTLING FOR THE TIMBER OF THE SHIP AND BARGE LOCK.

Upper Gates of Oak.—Two heel posts, 22 ft. × 18½ in. × 18 in. Two heads, 22 ft. × 18½ in. × 16 in. Two bottom bars, 22 ft. × 18½ in. × 16 in. Ten middle bars, 22 ft. × 16 in. × 15 in. Two angle braces, 25 ft. × 10 in. × 10 in. Two pointed sills, 21 ft. 5 in. × 18 in. × 16 in. The planking of Dantzic, 2½ inches thick.

Lower Gates of Oak.—Two heel posts, 40 ft. × 18½ in. × 18 in. Two heads, 40 ft. × 18½ in. × 16 in. Two bottom bars, 22 ft. × 18½ in. × 16 in. Ten middle bars, 22 ft. × 16 in. × 15 in. Two angle bars, 40 ft. × 10 in. × 10 in. Two pointed sills, 21 ft. 5 in. × 18 in. × 16 in. Four pieces for the sluice holes, 3 ft. 6 in. × 18 in. × 12 in. The planking of Dantzic, 2½ inches thick.

The gates, in the chamber of the locks, the same as the above.

Three platforms, elm or beech. Three main sills, 53 ft. × 24 in. × 18 in. Ten sills, 53 ft. × 18 in. × 12 in. Two ditto, 62 ft. × 18 in. × 12 in. Two sheeting piles, 62 ft. × 5 ft. × 3 in. Nine short pieces, in all 28 ft. × 12 in. × 12 in. Sheeting at the head of the forebay, 43 ft. × 15 ft. × 6 in.

TROW-LOCK OF OAK.

Upper Gates.—Two heel posts, 22 ft. × 15 in. × 12 in. Two heads, 22 ft. × 15 in. × 12 in. Four bars, top and bottom, 11 ft. × 12 in. × 12 in. Ten middle bars, 11 ft. × 12 in. × 10 in. Pointing sills, 11 ft. × 12 in. × 12 in. Planking of Dantzic, 2 inches thick.

Lower Gates.—Two heel posts, 40 ft. × 15 in. × 16 in. Two heads, 40 ft. × 15 in. × 16 in. Four bars, top and bottom, 11 ft. × 15 in. × 12 in. Sixteen middle bars, 11 ft. × 13 in. × 12 in. Pointing sills, 11 ft. × 12 in. × 12 in. Four short pieces for sluice holes, 3 ft. × 12 in. × 12 in. Planking of Dantzic, 2 inches thick.

PLATFORM TO UPPER GATES OF ELM OR BEECH.

One main sill, 33 ft. × 24 in. × 18 in. Two main sills, 33 ft. × 18 in. × 12 in. One sill at head of recess, 45 ft. × 12 in. × 12 in. Planking on platform, 24 ft. × 8 ft. 6 in. × 6 in. Sheeting piles at head of forebay, 45 ft. × 8 ft. × 3 in. One king post, 4 ft. × 12 in. × 12 in.

Lower Gates.—One sill at tail of inverted arch, 20 ft. 6 in. × 12 in. × 12 in. One main sill, 33 ft. × 24 in. × 18 in. One sill, 33 ft. × 18 in. × 12 in. One sill at end of platform, 45 ft. × 18 in. × 12 in. One king post, 4 ft. × 12 in. × 12 in. Sheeting piles at the end of the inverted arch, 20 ft. × 5 ft. × 3 in. Sheeting piles at the end of the platform, 45 ft. × 5 ft. × 3 in.

THE ENTRANCE GATES OF BASIN, OF OAK.

Two heel posts, 40 ft. × 18½ in. × 18 in. Two heads, 40 ft. × 18½ in. × 16 in. Two bottom bars, 22 ft. × 18½ in. × 16 in. Sixteen middle bars, 22 ft. × 16 in. × 15 in. Two angle braces, 40 ft. × 10 in. × 10 in. Two pointed sills, 22 ft. × 18 in. × 16 in. Planking of Dantzic, 2½ inches thick.

PLATFORM OF ELM OR BEECH.

One main sill, 55 ft. × 24 in. × 18 in. Three ditto, ditto, 55 ft. × 18 in. × 12 in. One ditto, ditto, 67 ft. × 18 in. × 12 in. One sheeting pile, 67 ft. × 5 ft. × 3 in. Three short king pieces, in all 15 ft. × 12 in. × 12 in. One sheeting, 40 ft. × 5 ft. × 3 in. One sill, 40 ft. × 12 in. × 12 in.

The heads and heels for the middle, lower, and also for the entrance gates to be provided either in

one length, or to be built, and iron-work provided by (or at the expense of) the contractor, as he may think proper.

Iron Pipes.—There are to be three of two feet diameter laid under the Canal, with shafts of masonry at each end, in the place marked on the said section thereof hereunto annexed; namely, one in the cutting below Purton, one near to Purton, on the south side, and one in the road leading from Cambridge near the feeder.

Culverts.—There are to be two stone culverts, one at the royal drough of six feet diameter, as marked in the margin, and one of four feet diameter in the drain leading by the Shepherd's patch, and marked upon the section. The former is to be built of ashlar stones, of a good quality, eighteen inches in bed, and the rubble backing of the stone formed in the new work, or may be taken from the stones belonging to the Company lying in the neighbourhood of Frampton. The latter is also to be built of similar materials, and both of Abathaw lime. The puddles over them not to be less than four feet thick.

Bridges.—There are to be five swing bridges on this part of the Canal, and placed in situations marked on the sections of the ground hereunto annexed, they are to be built in the following manner (viz.), to be built of freestone, of a durable quality, and approved of by the Resident Engineer.

The water way to be of the shape as represented on the plan thereof, and to the dimensions figured thereon, namely, twenty-nine feet six inches wide at the springing of the inverted arch; thirty-six feet at the level of the top of the water, and the abutment and side walls twenty feet high from the bottom level of the Canal. The building is to commence with an inverted arch of stones eighteen inches deep in the centre, and increasing regularly to three feet at the springing, in courses from ten to fourteen inches in thickness, and of such length as to break joint at least one foot. The length of this arch is fourteen feet as marked on the said plan thereof from A to B. The walls are to be six feet six inches wide at the bottom, and three feet at the top, besides the thickness of the piers which are described in the next clause.

The ashlars composing the front must be laid in regular courses from ten to fourteen inches in height, the stretchers to average eighteen inches on the bed, but none to be less than fourteen inches, the headers to be from two feet six inches to three feet long on the bed, and both headers and stretchers of such length as will break joint at least one foot on the face, the headers to be laid at every six feet.

The piers are to be built of the dimensions marked on the plan thereof, and carried up with good flat bedded stones to two feet six inches of the top, at which level a course of ashlar of twelve inches thick is to be laid for the whole length and width of the pier; upon this there is to be another course of stones eighteen inches in thickness; these courses are to be well jointed and bedded, and prepared in every respect in a workman-like manner to receive the circular iron plates upon which the metal rollers work, and other parts of the superstructure of the Bridges as described in the drawing. The circular walls at the approaches of the Bridges, as in the plan thereof, are to be built with good rubble stones, coped with ashlars two feet long on their beds, and twelve inches thick, secured with proper dowels.

All the ashlar stones to be properly squared, and close jointed, to have a neat chisel draught round their face, and the rest worked off with a pick or rough chisel.

The coping-stones to be two feet broad and twelve inches thick, with the arris rounded off.

The rubble backing must be of a good quality, and flat bedded, firmly put together, and set in good *forest* mortar.

The stones may be taken from the banks of the Canal already laid out in the neighbourhood of Frampton, or from those found in the work of a good quality.

TIMBER WORK.

All the timbers to be cut out of good Memel balk (except as after-mentioned), of the dimensions with reference to No. 1. marked on the plan, namely, No. 1. 5 segments, or ribs (oak), 6 in. × 6 in. No. 2. 5 bearing beams, 7 in. × 6 in. at the meeting ends, and 15 in. × 6 in. at the other end. No. 3. 10 pieces 6 in. thick, and cut out as on the plan. No. 4. 8 cross beams, 12 in. × 12 in. No. 5. 2 ditto 18 in. × 12 in. No. 6. 2 circular pieces (of oak), 24 in. × 9 in. No. 7. 10 pieces 12 in. × 6 in. at one end, and 7 in. × 6 in. at the other end. No. 8. 8 pieces framed to each rib and bearing beam, 6 in. × 6 in. No. 9. 2 springing pieces, 6 in. × 6 in. No. 10. 4 pieces at the joint *a* 7 in. × 6 in. No. 11. 2 cross pieces 6 in. × 4 in. Two cross pieces rabbetted down to No. 3. 6 in. × 4 in. The hand rail, namely, 28 posts 6 in. × 4 in. and 12 rails 4 in. × $1\frac{1}{2}$ in.

The covering plank (elm) three inches thick. The whole of the scantling to be of the respective lengths as on the plan.

CAST IRON WORK.

Four circular plates ten feet diameter, seven inches broad in the rim, and two inches thick, with four arms in the bottom plate, and six in the top ditto; thirty-two rollers, eight inches diameter on the largest end, six inches long, with spindles and collars working round the pivots; two circular meeting plates 15 in. × $1\frac{1}{4}$ in. Two circular plates at the tail of the bridges 15 in. × 1 in. Two pivots and stops. The length to be taken from the plan thereof.

Malleable iron in bolts, screws, and nails, about eight cwt. in all.

WASTE WEIRS.

To be constructed upon a plan furnished by the Resident Engineer, and in such situations as he may direct; but the expense of constructing such weirs not to exceed the sum of £1000.

The contractor must personally attend the execution of the works, or keep some experienced and responsible person constantly there, with whom the Resident Engineer can at all times confer; he must find and provide all tools and implements, and a sufficient number of labourers and workmen for carrying on every part of the foregoing described works, and clear the works of water from Sharpness Point to the Cambridge Arm during the execution of his contract.

All the work, inasmuch as respects the quality of the materials, cutting and dressing the stone, the manner and form of laying them, together with every other part of the works, to be performed to the satisfaction of the Resident Engineer, and under his direction; and all and every part to be executed in the most complete and substantial manner, according to the annexed plans and foregoing specifications of the several works to be performed.

In case any difference of opinion should arise between the Company's Resident Engineer and the contractor respecting the explanations and meaning of any part of the plans and specification of the works, or any other matter or thing connected with the execution of the works herein specified, the same shall be left to and determined by Thomas Telford the principal Engineer of the said Company, and also the Engineer of the Commissioners for the issue of Exchequer Bills in the above indenture referred to, whose opinion shall be conclusive; and, in case of the death of the said Thomas Telford, by the person who shall, in that event, be appointed Engineer of the said Commissioners, and such person as may be appointed by the said contractor; and, in case of a difference between the said parties, to such person as they shall jointly appoint.

The contractor to have the use of the ashlar stone lying near Pegthorn bridge; and if there shall be any stones at the other bridges, except at the Stroud water navigation, they also are to be allowed to the contractor for the use of the works.

RIVER WALL.

FISHMONGERS' HALL EMBANKMENT.

Plates XCV, XCVI, and XCVII.

The erection of the present "London Bridge," and the formation of the approaches thereto, required the removal of the Hall of the Fishmongers' Company, which was erected from a design of Sir Christopher Wren, on the site of a former hall belonging to the same Company, after its destruction in the great conflagration of the City in 1666. For the erection of the New Hall a very substantial embankment was raised, protected from the action of the water of the river Thames by the wall which is represented in plan and section in the plates above referred to, and which, from the fulness of the engraved particulars, are themselves sufficiently explanatory of their construction.

DEPTFORD PIER.

CAST IRON PILING FOR WHARFS, &c.

Plate XCVIII.

Our example of this modern kind of wharfing is now (August, 1837) in progress of execution, from the designs, and under the superintendence, of George Landmann, esq., Civil Engineer, for the "Deptford Pier and Improvement Company." It is situated at the eastern extremity of Her Majesty's Dock-yard, and is already completed to the extent of about one hundred and sixty feet in length, and will be continued to about eight hundred feet.

The work consists of main piles, driven at equal distances of six feet, the intermediate spaces, or bays, being filled with sheet piles to the height of the level of the present surface of the ground, as left bare by the ebbing of the tide: each of the intervals above the sheet piles is then filled by three equally-sized iron plates, which slide down in grooves formed by projecting flanges on the sides of the main piles; the lower edge of the bottom plate (or pannel) has a flange to overlap the top edge of the sheet piles upon which it rests. The main piles are strengthened in position, and prevented from being thrust outwards by the pressure of the backing, by three iron land-ties, which are bolted to stay piles of timber driven in the ground at some distance in the rear (in front of the old wharf wall). A wall of concrete of lime and gravel is then formed at the back of the iron piling, and the whole surrounded by a coping of the best Cornish granite.

The details of the construction may be understood from Plate XCVIII. Figure 1 represents a transverse section, showing the manner of connecting the main piles to the stay piles by three $1\frac{3}{4}$-inch iron land-ties. This is likewise shown in plan, fig. 3, which also exhibits the manner of connecting the sheet piles to the waling timber, each sheet pile being connected therewith by two $\frac{3}{4}$-inch screw bolts, the heads of which are countersunk (and appear in the left-hand bay of the elevation, fig. 2). The waling

timbers are notched into the guide piles, and bolted thereto, the upper waling with 2-inch bolts, and the lower waling with 1-inch bolts. The whole of the stay and guide piles, and the waling pieces, are whole timbers, not less than thirteen inches square, of strong sound Memel fir. The waling extends along the whole length of the iron front, and each iron main pile has one stay, and one guide pile behind it, as shown in the section, fig. 1.

The main piles are cast in two pieces to facilitate the driving, and also to lessen the danger of fracture in that operation; their joining is shown at *a* fig. 1. The lower part, or counter-pile, was first driven to the required depth, namely, about twenty-five feet below the present surface of the ground, being eighteen feet below low-water mark (it being the intention of the Pier Company ultimately to remove as much of the ground from the front of the wharf as will leave a sufficient depth of water for steam vessels to come alongside at all times of the tide). The full required length of the main pile was then obtained, by fixing the upper pile in its place, on the top of the lower one: for this purpose, a projecting flange was cast on the back of the joining ends of each pile, which are held together by three $1\frac{1}{4}$-inch screw-bolts, as may be understood by reference to fig. 5, the upper figure in which shews the two piles fastened together by the three bolts passing through the flanges, and the lower figure shews the horizontal section or plan of the piles, with the projecting flange and bolts, also the grooves for the sheet piles and upper plates to slide down to their respective berths. The main piles, which are hollow throughout, are not continued of iron to the point for penetrating the ground, but a timber shoe, pointed with iron, was provided for this purpose, which fitted into the bottom of the counter-piles: the form, &c. of the shoe is shown in plan and elevation, fig. 6.

The dark portion of the main pile in fig. 1 is a section of the sheet piling and upper plates, showing how the latter overlaps the upper edge of the former; which may also be seen in the elevation, fig. 2. The middle plate is connected to the upper and lower plates by four $\frac{3}{4}$ screw-bolts, and the whole of the joints in the iron work were stopped and pointed with the best iron cement.

The ground was excavated to receive a wall of concrete (of lime, sand, and well-screened gravel) at the back of the iron piling, as shewn in fig. 1. It was in the first instance expected, that some portion of the gravel required for the concrete would be obtained from the excavation, and the remainder got from the front of the wharf; but in this the parties were disappointed, and it was ultimately obtained from the bed of the river above bridge by a dredging engine.

The coping is of the best Cornish granite, having a dowel fixed between each two stones, four inches square and nine inches long, as shewn in the plan, fig. 4. The remainder of the space at the back is then filled up to the level of the top of the coping, the intended level of the wharf when completed.

In the process of driving the main piles, great care was necessarily exercised to prevent breaking them; nevertheless, some few were fractured in the operation. Such of them as broke off near the top were made available after being driven to the required depth, by splicing thereto a similar piece cast for the purpose, to make them of the requisite length. The other broken ones that could not be so repaired were withdrawn, which in some instances was attended with great labour and loss of time, in consequence of their being so firmly held by the hard binding strata into which they were driven: in one instance, a main pile broke after entering eight feet in the ground; and before it could be withdrawn, it had consumed the labour of eight men during six tides (averaging six hours each) with all the power they had the means of applying, consisting of pulleys and crabs, the rising of a barge with the tide, &c.

The stratum which the piles had to pierce consisted, for the first six feet, of made ground; the next, which varied from six inches to two feet, was a conglomerate or pudding stone of sand and gravel, forming a perfect rock; and from the specimen shown to us, we should consider it to be what is commonly called Blackwall rock, which is a concrete of gravel and the oxide of iron, obtained from the land-springs flowing through the gravel beds: below this, about two feet of red gravel succeeded, then a loam which continued

the remaining depth, about twenty-seven feet. The above may be said to be the average state of the soil through which the piles were driven; but immediately in front of the old wharf, where the stay piles are fixed, an indurated sand of a coarse grit was occasionally found, through which it was impossible for the stay piles to pierce; this appeared to arise from the elasticity it possessed: it was therefore obliged to be dug away; and, after the stay piles were put in possession, to be filled in again.

An ordinary crab engine was employed in driving the piles, the monkey weighing about sixteen hundred weight; the fall was confined to four feet, which, after numerous experiments, was found to answer best, having due regard to the safety of the iron piles; great care was taken to fix the engine so that the fall should be in the sloping direction the pile was required to take. Cast-iron dolleys, weighing about $1\frac{3}{4}$ cwt., and about eight inches high, were fitted to the tops of the main piles to receive the blows; and, to obviate the jarring, a piece of good elm $\frac{5}{8}$ inch thick was laid upon the dolly for the monkey to fall upon; this was found to answer the best, after trying a variety of substances.

The driving the main piles, particularly, was found to be a tedious operation; to drive some of these to the required depths, it has occupied twenty-one tides, and others eighteen tides (averaging six hours each). At the commencement of driving each pile it has often penetrated $\frac{1}{4}$ inch at one blow; but after entering about seven or eight feet, it has required from twenty-five to thirty blows to drive it the same quantity. On one occasion it required six hours' hard labour to penetrate three inches. The average, however, may be stated to be, at the depth of ten feet, fifty blows to one inch: occasionally a spot of more favourable ground was met with; in one of these, a pile entered six inches with seventy blows, and in another, a pile penetrated six inches in one tide, or about one inch per hour, and the following day went down eight inches in the same time. The sheeting piles, from the greater sharpness of their points and less sectional area, were driven much more readily. The average may be stated as four sheeting piles in thirty-four tides, or about $\frac{1}{4}$ inch to each blow.

The weight of one of the main piles, which was twenty-six feet long, was $29\frac{1}{2}$ cwt. The sheeting piles were seventeen feet long, one foot three inches wide, and about one inch and a quarter in thickness, averaging in weight 15 cwt. 1 qr. 10 lbs.

The iron plates or pannels which are fixed above the sheet piles measure six feet three inches by four feet two inches, and weigh about $12\frac{1}{4}$ cwt.

In addition to our frequent personal inspection of these works, we are indebted for the principal facts contained in the foregoing statement to Mr. John Rodbet, who superintended the work for the Contractor, the late Mr. Cutts.

HIGH BRIDGE, OVER THE RIVER TRENT, STAFFORDSHIRE.

DESIGNED BY, AND EXECUTED UNDER THE DIRECTION OF, J. POTTER, ESQ.

SURVEYOR OF PUBLIC WORKS FOR THE COUNTY OF STAFFORD.

PLATES XCIX. C. CI.

SPECIFICATION OF WORKS.

MASON'S WORK.

SPECIFICATION of the masons' work of the abutments for the Iron Bridge intended to be erected over the river Trent at a place commonly called High Bridge, near to Handsacre, in the county of Stafford.

1. The footings to be in three courses laid on level beds; the courses to be not less than one foot thick, and the front or outside courses to be laid header and stretcher alternately; the stretchers to be not more than four feet long, and to average two feet in width upon the beds; the headers to average four feet in length, and two feet upon the beds; the stones to be all properly worked on the beds, that is, to have a tool draught round them, and dressed off fair between with a point or pick; the joints or ends of the stretchers to be squared their whole length, and the joints of the headers squared in the width of the stretchers, and the other parts dressed or squared with a pick: all the space between the courses to be filled in with ashlar of the same thickness as the outside courses, the beds prepared as before directed, and the sides and ends squared with a pick, and laid in proper bond to fall in with the outside courses; and when a course is finished, to be grouted; the whole surface is then to be dressed off level before another course is begun to be set.

2. The front courses of the abutments, cutwaters, and wing walls, to be not less than one foot thick, laid on level beds with proper bond, that is, the joints to overlap about eight inches, header and stretcher alternately; the headers to average three feet six inches in length, and one foot six inches wide; the stretchers to be not more than four feet in length and one foot six inches wide. The beds of the stones to be all worked fair and the joints squared the width of the stretchers, and the face of them clean tooled. The wing walls to be built curvilinear on the plan, finishing with octangular piers, and battering in a curve line three feet in the whole height; the joints to be rusticated.

3. The hearting of the abutments, that is, between the outside courses, to be worked to fall in with the radii of the arch, as shewn on the section. The stone composing this part of the abutments to be about one foot thick where they terminate at bottom, and when they extend to require stones more than eighteen inches thick, they may be in two courses if required; the stones must average not less than two feet upon the beds, and from three to four feet in length; the beds to be fair dressed by a tool draught round, and dressed off between with a pick; the heading and side joints squared and set in proper bond as before expressed; and when one course is set, it must be dressed off fair to its radii and grouted, before another course is begun.

4. The springing stones, that is, those on which the springing plates of the arch are to rest, to be four feet on the face on which the plates rest; the projection, or string course, to be worked on the same stones. These stones to be not less than three feet on the beds.

5. The cornice and plinth of the wing, walls, and piers to be worked according to the drawing,

that is, to match the iron cornice. The caps of the piers and cutwaters to be each in one stone, and worked as shewn on the drawings.

6. To be a puddle of clay three feet thick put in against the back of the abutments, and wing walls carried up with the masonry as it proceeds, and filled in behind with spoil (got out from the foundations) to the extent of the wing walls, and well rammed down to keep the puddle in its proper place.

7. The stone to be used for the works to be got from Tixall or Weston Quarry, or any other of as good a quality; it must be free from clay holes or dry vents, and all to be set on its natural or quarry bed.

8. The mortar to be composed of barrow lime and river or drift sand, two parts of sand to one of lime; mixed up in small quantities, as it is used, with as little water as possible, and well beat with a beater before it is used. The grout must be made with the same lime mixed up with coarse sand and small gravel, in the same proportion as above mentioned.

9. The Contractor must find all materials, tools and utensils, for his part of the work, and shall not let any part of the work, except quarrying the stone, and carriage of the same and other materials, to any person, but the whole to be done by men on day wages. The excavating the earth for the foundations, pumping the water, and all piling, planking, and grating, as may be necessary for the foundations, to be done by the County.

10. The orks are to be done under the superintendence of the surveyors of the public works of the county ot Stafford, or such surveyor as the justices assembled in quarter sessions shall at any time hereafter appoint; and should it at any time appear during the execution of any parts of the works to such surveyor that the Contractor is neglecting or doing any part of the work contrary to the true meaning and intent of this specification, the magistrates shall have it in their power to take the work out of his hands, and employ others to finish it; and what money may be due to the said Contractor, to remain in the hands of the treasurer of the county till the whole is completed; and any loss that may be sustained by the neglect or misconduct of the said Contractor, to be paid for out of it.

IRON WORK.

Specification of the iron work for a Bridge intended to be erected over the river Trent, at a place commonly called High Bridge, near to Handsacre, in the county of Stafford.

1. Upon each abutment is to be a springing plate of cast iron, each cast in one piece, and to have shoulderings and sockets to receive the ends of the ribs. Each plate is to be of the form and dimensions as shewn upon the drawings. The back of each socket, or the part against which the ends of the ribs will abut, is to be clipped, and made to have a true and even face to the exact radius of the arch.

2. There is to be one arch of 140 feet span, and rising 14 feet; the arch is to be composed of five ribs, each cast in seven pieces of equal lengths. The ribs are to be thirty-six inches deep, in the direction of the radius, and of the exact shape and dimensions as shewn upon the drawings. The parts of each rib and the ribs are to be connected by cast-iron tie or connecting plates, each cast in one piece, and passing quite across the arch,—the parts composing each rib are to have flanges cast upon each of the ends which abut against the connecting or tie plates, and are to be secured to them by three 3-inch square threaded wrought iron screw pins in each flange. Each flange is to be clipped, and made true over the whole of its surface to the exact radius of the arch, so as to have a solid and true joint. The ends of the parts of the ribs which are to be fixed in the sockets of the springing plates are to be clipped, and made true over their whole surface of section, so that they may have a sound, solid, and true abutting joint. The parts of each tie or connecting plate against which each part of the rib abuts must, for the whole area of each flange, be made to the exact radius of the arch, and be clipped and made to have a true and even face. Joggles are also to be cast upon each tie or connecting plate, which

are to fit into the joggles cast on the ends of the parts of the ribs. Both the male joggles upon the tie or connecting plates, and the female joggles at the ends of the ribs, are to be made to the radius of the arch, and clipped, and made true over their whole surface, so that each joint may be solid and true throughout.

Upon the top of each of the ribs is to be a shouldering, running its whole length, having sockets to receive the joggles upon the bottoms of the spandrils.

Diagonal braces of cast iron of the same section, form, and dimensions, and disposed in the manner as represented in the drawings are to be used: each of the parts composing the braces are to abut against the ribs in the situations and in the manner shewn upon the drawings, and secured to them by keys and cotters, or wedges filed and made true upon their edges. The parts of the braces which abut against the ribs, and also the face of the snugs or bed pieces, cast upon the ribs to receive them, must be chipped, so that they may have a true solid joint.

3. The spandrils are to be of the same form and dimensions as shewn upon the drawings. The spandrils over each rib are to be the same in every respect, excepting that upon the outside face of the outside spandrils a fillet must be cast, running round each opening as shewn upon the drawing: the fillet to be $1\frac{1}{2}$ inch wide, and projecting $\frac{3}{4}$ of an inch.

Upon the bottom of the spandrils at the point of each lozenge must be cast joggles to fit into sockets on the tops of the ribs. Ears are also to be cast at the same places, the situations of the joggles and ears marked upon the drawings B,B,B. At the central intersection of each lozenge there must be a brace running quite across the Bridge; each must be done as shewn upon the drawing, viz. having a wrought iron screw bolt $1\frac{1}{2}$ inch in diameter, passing through cast iron tubes, with washer plates, &c. quite across the Bridge These braces are to be placed in the situations as marked A,A,A, upon the drawings. The spandrils may be cast in any convenient lengths, and connected by flanges of proper strength, and $1\frac{1}{2}$ inch wrought-iron screw pins.

The outside spandrils are also to have a flange cast on their top, running the whole length of the bridge, to bed the cornice, &c. upon.

4. The cornice is to be of the same form and dimensions as shewn upon the drawings, having strengthening pieces cast inside, not further asunder than three feet. It must be cast in lengths not exceeding nine feet, and each piece is to be connected to the other by internal flanges, and three $1\frac{1}{4}$ inch wrought-iron screw pins in each joint. The bottom of the cornice will lay upon a flange cast upon the tops of the outside spandrils, and be secured to it and the road plates by $1\frac{1}{2}$ inch wrought-iron screw pins, two in each road plate.

5. The plinth is to be of the dimensions and form as shewn upon the drawings; it must be cast in lengths not exceeding eight feet six inches; each piece to be connected to the other by a dove-tailed joint. Ears are also to be cast on the bottom of each side, to secure it to the top of the cornice, by $1\frac{1}{4}$ inch wrought-iron screw pins, not more than two feet asunder. Socket holes are to be cast in the top of the plinth, to receive the palisade bars.

6. The palisade bars are to be $1\frac{1}{4}$ inch square, placed arris ways, and not more than six inches asunder from centre to centre. The handrail is to be of the same dimensions and form as shewn upon the drawings, having sockets cast on the under sides to receive the tops of the palisade bars, and it is to be screwed to the top of every sixth palisade bar, with a counter-sunk headed screw; and it must be secured or connected with the pedestals in the manner shewn upon the drawings. The pedestals are to be of the same dimensions and form as shewn upon the drawings, having sunk pannels on the front and back; internal flanges to be cast on the top to receive the handrail, and the caps are to be put on with counter-sunk headed screws. Brackets are also to be cast on each side of every sixth palisade bar, of the same form as shewn upon the drawing, and secured by screw pins to the plinth.

7. The covering or road plates are to be reticulated, and of the same dimensions and form as shewn upon the drawings, having flanges cast on their under sides to receive the bearers or tops of the spandrils; they are to be secured to the top of the centre spandrils, and to the flanges cast on the top of the outside spandrils, by 1½ inch wrought-iron screw pins, two in each joint. They are also to be connected to each other by flanges cast on their under sides, and two 1½ inch wrought-iron screw pins in each joint.

8. None of the castings are to be run from the blast furnace, but the whole must be made from good No. 2. pig iron, of a quality satisfactory to the surveyor or surveyors of the works of the county of Stafford. All the screw pins, nuts, washers, keys, cotters, wedges, &c. are to be made of the best malleable iron. All the joints are to be made in a good workmanlike manner, and the whole of the work must be fitted and fixed at the Contractor's works, and inspected by the county surveyor previous to its being sent off. All the work must be moulded, wrought, fitted, and erected in a substantial and workmanlike manner, and to the entire satisfaction of the county Surveyor or Surveyors.

9. The Contractor must find and pay for all patterns, materials, tools, cement, tackling for fixing his work, and all other utensils or requisite things connected with the construction and fixing his part of the work. The estimates are to be given in a gross sum, and must include carriage of all materials to, and fixing the work at, the place of the intended erection.

10. The county of Stafford will be at the expense of the whole of the masonry of the abutments, and cutting and letting-in the iron work into the masonry; and will also provide centring for turning the arch.

11. Should any alteration be made hereafter in the dimensions or method of executing any part of the work, the extra price or deduction, whichsoever it may be, shall be agreed upon by the Contractor and the county Surveyor or Surveyors, before such part or parts of the work are put into execution. But such alterations shall only be considered as affecting the matter or object then specified, and not have any tendency to annul the general contract.

12. The whole of the works are to be under the superintendence of the Surveyor of the Public Works of the county of Stafford, or of such surveyor or surveyors, person or persons, as the Justices assembled in Quarter Sessions shall at any time hereafter appoint. And should it appear, at any time during the execution of the works, that the Contractor is neglecting or doing any part contrary to the true spirit and meaning of this specification and drawings attached, then the Magistrates shall have it in their power to take it out of his hands, and employ any other person or persons to complete it; and what money may remain due to him shall remain in the hands of the Treasurer of the Public Stock of the County of Stafford till the whole work is completed, and any loss that may be sustained through the neglect or misconduct of the said Contractor to be paid for out of it.

13. The whole of the work must be delivered, fixed, and completed on or before the day of in the year .

The bridge was erected in the year 1830. The total weight of the iron work, which was executed by the Colebrook Dale Company, was 340 tons.—The whole cost of the bridge was as follows:—

Iron work, delivered, fixed, and completed - - - - - - - - -	£3800
Masonry - - - - - - - - - - - - - - - - -	3193
Foundations, which were piled according to the most approved method; and the approaches, which are of considerable length and height - - - - -	2500
	£9493

Plate XCIX.

Contains the plan and elevation of the bridge.

Plate C.

Fig. 1. End view of abutment.
2. Section of abutment.
3. Section of wing wall.
4. Plan of ribs and diagonal braces.
5. Elevation of part of the spandrils.
6. Cross section of part of the bridge.
7. Plan of the springing plate.
8. Section of ditto ditto.
9. Elevation of ditto ditto.
10. Elevation of tie plate.
11. Plan of do. do.
12. Section of do. do.
13. Plan shewing the method of connecting the external ribs to the tie plates.
14. Plan shewing the method of connecting the internal ribs to the tie plates.
15. Plan shewing the method of connecting the diagonal braces to the ribs and tie plates.
16. Elevation shewing the method of connecting the diagonal braces to the ribs and tie plates.
17. Section shewing the method of connecting the ribs to the tie plates, and the spandrils to the ribs.

Plate CI.

Fig. 1. Longitudinal section of the road plate.
2. Plan of the under side of the road plate.
3. Transverse section of the road plate.
4. Section of cornice, plinth, &c.
5. Elevation of cornice, plinth, pedestal, and railing.
6. Section of top of pedestal.
7. Horizontal section of top of pedestal.
8. Horizontal section of pedestal through the centre.
9. Horizontal section of bottom of pedestal.
10. Horizontal section of plinth, shewing the manner of connecting it to the cornice.

CANAL BRIDGES AND LOCKS, GATES, &c.

Plate CII.

Plan and elevation of a swivel bridge of iron.

Plates CIII. and CIV.

Plan, elevation, and section of a bridge of the ordinary construction for carrying a road over a Canal.

Plate CV.

Plan and longitudinal section of a lock on the Birmingham and Liverpool Canal.

Plate CVI.

Plan of a lock, with a single gate, on the Birmingham Canal.

Plates CVII. and CVIII.

Plan and elevation, &c. of the lock gates, valves, and the requisite machinery at the Prince's Dock, Liverpool.

Plate CIX.

Double valve, with one foot lift, for tide locks.

Plate CX.

Lever valve, lock gates of the Rochdale Canal.

Plate CXI.

Mersey and Irwell Canal Boats.

Plate CXII.

Boats used on the Grand Trunk and Birmingham Canals.

THE DOCKS AND PORT OF LIVERPOOL.

Plate CXXXI.

Our engraving contains a plan of the river Mersey at Liverpool, shewing the various soundings, and that magnificent line of Docks, the total area of which for the accommodation of shipping amounts to upwards of ninety acres, the whole enclosed by a river wall, nearly two miles and a half in length, having quay space to the extent of nearly eight miles.

Liverpool was originally a small fishing village, so inconsiderable at the time of the Norman Conquest, (if it then even had an existence,) as not to obtain a notice in "Domesday Book;" and it was not till the conquest of Ireland by Henry the Second, in 1172, who used this port for the embarkation of his troops to that country, that its importance was appreciated, or that it obtained any permanent commercial advantages. This circumstance, with the gradually increasing commerce consequent on the connection ever since maintained between the two countries, and the excellence of its port, doubtless laid the foundation for its present magnitude and prosperity. Henry the Second granted the town its first charter in 1173; King John granted a second in 1207; and Henry the Third not only confirmed the former charters, but constituted it a free borough for ever, with a merchant guild, or society, and other liberties. In 1332 another charter, confirming the former concessions and liberties, was granted to Liverpool by Edward the Third. And upon the breaking out of the memorable wars with France in 1338, the King, in order to strengthen the naval power of his country, required all the ports in the kingdom to make contribution according to the means which each of them possessed. The levies thus imposed, which amounted in the gross to 700 vessels, and 14,141 men, afford an insight into the comparative importance of the ports of England at that period; and the following return of the quotas required from several of them serves to shew what station the town and port of Liverpool then occupied:

London - - - -	25 ships and	662 men.
Bristol - - -	24 ditto —	600 ditto.
Hull - -	16 ditto —	466 ditto.
Portsmouth - - -	5 ditto —	96 ditto.
Liverpool - - -	1 bark —	6 ditto

Little is known respecting the commercial state of Liverpool from the 14th to the beginning of the 16th century, when Leland, in his tour through the kingdom visited it, and has left on record a favourable account of it. Its growth, for a long period, was nevertheless slow, and even at times retrograded; for, in 1571, the inhabitants of the town petitioned Queen Elizabeth to relieve them from a subsidy which had been imposed on them, "in which it is styled, 'her Majesty's poor decayed town of Liverpool;' terms on such an occasion not likely to have been used if the fact were not indisputable." But little is known of the particulars of the commercial history of Liverpool for the next century, but that it continued on the whole to improve there can be no doubt; in 1650, fifteen vessels, from fifteen to twenty tons each, belonged to the town, most of them, proabably, were employed in the Irish and Coasting trade. The history of the commerce of Liverpool is principally remarkable for the contrast which its former insignificance furnishes, when compared with its present greatness. It is like the tiny rill which gives origin to a mighty river, insignificant in itself, but interesting as the commencement of a capacious stream, capable of bearing navies on its waters, and spreading health and fertility through distant lands.

The Port of Liverpool owes its greatness to its unrivalled geographical situation, placed near the mouth of a deep and navigable river, in which the anchorage is secure from the effects of those casualties

which render many of our sea-ports unsafe, and which too often has proved the destruction of many lives and much property, even in our harbours. The river Mersey at Liverpool was admirably adapted by nature for the safe anchorage of commercial vessels of every size, even before the formation of its numerous docks. It now not only possesses the commerce of the neighbouring district, but through its extensive canal communication, it has become the port of Lancashire, of the West Riding of Yorkshire, Cheshire, Staffordshire, and even of Warwickshire. Thus it concentrates the foreign trade of districts not only vast in extent, but abounding above all other in mineral wealth, manufacturing skill, and all the elements of national prosperity. Through the Port of Liverpool are poured into the interior the raw materials of our manufactures, and all the various commodities which minister to the wants and wishes of a wealthy and highly-civilised people; and through the same port are sent forth, to every corner of the globe, those innumerable products of British industry, which render England the workshop of the world.

The following Tables will exhibit at one glance a view of the progress of the commerce of Liverpool, from the time indicated by the earliest authentic documents to the present day, when it has attained to such national importance:

Table shewing the amount of the Liverpool Dock duties for the following years, and the number of vessels entering the Docks from 1757, and the tonnage of the same from the year 1800:

Year.	No. of Vessels.	Tonnage.	Duties. £.	s.	d.	Year.	No. of Vessels.	Tonnage.	Duties. £.	s.	d.
1734	-		810	11	6	1796	4738	-	12,377	7	7
1752		–	1,776	8	2	1797	4528		13,319	12	8
1755	—		2,417	13	11	1798	4478		12,057	18	3
1757	1371	—	2,336	15	0	1799	4518	—	14,049	15	1
1758	1453	—	2,430	6	3	1800	4746	450,060	23,379	13	6
1759	1281		2,372	12	2	1801	5060	459,719	28,365	8	2½
1760	1245	–	2,330	6	7	1802	4781	510,691	28,192	9	10
1761	1319		2,382	0	2	1803	4791	491,521	28,027	13	7
1762	1307	-	2,526	19	6	1804	4291	448,761	26,157	0	11
1763	1752	—	3,141	1	5	1805	4618	463,482	33,364	13	1
1764	1625	-	2,780	3	4	1806	4676	507,825	44,560	7	3
1765	1930	–	3,455	8	4	1807	5791	662,309	62,831	5	10
1766	1,608	—	3,653	19	2	1808	5225	516,836	40,638	10	4
1767	1704	-	3,615	9	2	1809	6023	594,601	47,580	19	3
1768	1808	—	3,566	14	9	1810	6729	734,391	65,782	1	0
1769	2054		4,004	5	0	1811	5616	611,190	54,752	18	5
1770	2073	—	1,142	17	2	1812	4599	446,788	44,430	7	11
1771	2087	—	4,203	19	10	1813	5341	547,426	50,177	13	2
1772	2259	–	4,552	5	4	1814	5706	548,957	59,741	2	1
1773	2214	—	4,725	1	11	1815	6440	709,849	76,915	8	8
1774	2258		4,580	5	5	1816	6888	774,243	92,646	10	9
1775	2291	-	5,384	4	9	1817	6079	653,425	75,889	16	4
1776	2216		5,064	10	10	1818	6779	754,690	98,538	8	3
1777	2361	–	4,610	4	9	1819	7849	867,318	110,127	1	8
1778	2292	—	4,649	7	7	1820	7276	805,033	94,412	11	10
1779	2374	—	4,957	17	10	1821	7810	839,848	94,556	9	1
1780	2261	—	3,528	7	9	1822	8136	892,902	102,403	17	4
1781	2512		3,915	4	11	1823	8916	1,010,819	115,783	1	6
1782	2426	-	4,249	6	3	1824	10,001	1,180,914	130,911	11	6
1783	2816		4,849	8	3	1825	10,837	1,223,820	128,691	19	8
1784	3098		6,597	11	1	1826	9601	1,228,318	131,000	19	0
1785	3429	-	8,411	5	3	1827	9592	1,225,313	134,472	14	3
1786	3228		7,508	0	1	1828	10,703	1,311,111	141,369	15	7
1787	3567	-	9,199	18	8	1829	11,383	1,387,957	147,327	4	11
1788	3677		9,206	13	10	1830	11,214	1,411,964	151,329	17	10
1789	3619	-	8,901	10	10	1831	12,537	1,592,436	183,455	4	3
1790	4223	—	10,037	6	2½	1832	12,928	1,540,057	170,047	6	11
1791	4015	—	11,645	6	6	1833	12,961	1,590,461	182,980	16	1
1792	4483	—	13,243	17	8¼	1834	13,444	1,692,870	191,729	17	8
1793	4129		12,480	5	5	1835	13,941	—	217,825	0	8
1794	4265		10,678	7	0	1836	14,959	—	244,814	5	9
1795	3948	—	9,368	16	4	1837	15,038	—	191,330	15	9

Number of Vessels, their tonnage, and the men employed to navigate them, belonging to the Port of Liverpool, in the following years:

Year	Vessels.	Tons.	Men
1565	15	259	89
1701	102	8,619	—
1787	445	72,731	
1790	504	80,603	
1826	732	141,097	7,829
1828	793	158,446	8,900
1829	806	161,663	9,091
1830	811	163,663	9,171
1831	820	166,963	9,270
1832	839	172,663	9,620
1833	878	184,363	10,214
1834	937	202,063	11,397

Whilst the commerce of Liverpool has been increasing steadily, and spreading to all quarters of the globe, the facilities supplied by the port for the reception and safe preservation of vessels, and for the despatch of business have increased not less rapidly. The first dock ever constructed in Liverpool was opened in the year 1690; and although this dock was filled up in 1827, and has become the site of the new custom house, yet the amount of dock accommodation has increased from that time until the present day, when the docks of Liverpool are so extensive, that with those now in progress they will contain a total area of water of 111 acres 4257½ yards, and presenting a broad quay space 9 miles and 83 yards long. The extreme length of the river wall, when completed, will be 2 miles and 1087 yards.

Table, shewing the area of water and the quantity of quay space of the Docks, exclusive of the graving Docks, &c.

Names.	Area of Water in Acres and Decimals	Quay Space in lineal Yards.
BASINS DRY AT LOW WATER.		
Prince's Basin	4·320	509
Seacombe Basin	0 373	188
George's Basin	3·383	455
George's Ferry Basin	0·278	160
Old Dock Gut (entrance to Canning Dock)	1·598	447
King's and Queen's Basin	5·039	601
Brunswick Basin	4·881	572
South Ferry Basin	0·605	205
WET DOCKS.		
Clarence Dock	5·767	740
Its Lock	0·289	174
Half Tide Basin	3·637	586
Waterloo Dock	5 576	700
No. 1 lock	0 725	275
Half of passage	0·055	37
Prince's Dock	11·127	1187
Its two locks	0·677	426
George's Dock	5 032	615
Its two passages	0·504	356
Canning Dock	3·945	500
Salthouse Dock	4·651	666
Its passages	0·106	95
King's Dock	7·693	800
Its passages	0·112	75
Queen's Dock	10·382	1082
Its two passages	0 258	175
Half Tide Dock	2 591	407
Its passage	0·134	90
Brunswick Dock	12·438	1005
Its passage	0·129	87
Half Tide Basin	1·910	483
NEW DOCKS.		
Dock (next Waterloo Dock)	5·792	693
Its entrance Lock	0·108	72
Half of two passages	0·110	74
Dock (next Clarence Dock)	6·171	738
Half of passage	0 055	37
Lock	0 725	275

"The expense of executing these stupendous excavations has been immense; and it appears from official vouchers that the cost of making the Prince's Dock alone amounted to 461,059*l.* 19*s.* 4*d.* exclusive of the land, the estimated value of which is 100,000*l.* This application of the wealth of the town is the result of an enlightened policy, which enriches at once the commercial community for whom the accommodation is intended, and the opulent body by whom it is afforded. The King's Dock and the Prince's Dock present their noble marine parades, commanding extensive views of the harbour and of the river, with a beautiful landscape on the opposite shore; the view to the west being terminated by the eminence on which stands Bidston Lighthouse, and the extensive range of signal-posts. The Duke of Bridgwater's representatives have a small dock of their own between the King's Dock and Salthouse Dock, in which their Canal business carried on by the flats and barges is transacted; and the trustees of the Mersey and Irwell Navigation are provided with similar accommodation at the south end of George's Dock. The accommodation for steam and ferry boats is found in the Seacombe Basin, George's Ferry Basin, and South Ferry Basin, together forming an area of 6,076 square yards."

"Within the last few years, the entrance to the river Mersey has been rendered much easier, by the discovery of a new channel, lying between the two, which have so long been the only inlets by which vessels could wind their way through the sands which spread round the mouth of the river. This channel admits the passage of vessels of considerable size even at low water; and is found especially useful by steam vessels to which a detention of even a few hours is a most serious inconvenience. The public are indebted for this valuable accession to the commercial facilities of the Port, to the Dock Committee, and to their able and accomplished assistant, Captain Denham, of the Royal Navy."

The mean column of water which flows into the river Mersey, at the equinoctial or highest spring-tides, is about thirty-three feet five inches; at the mean spring-tides, twenty-nine feet seven inches; at the mean neaps. fifteen feet four inches; and at the lowest neaps, only twelve feet nine inches.

The Borough of Liverpool has to boast not fewer than seventeen Royal Charters, from the reigns of Henry II. to that of George IV. as enumerated in the following Table:

1. 19 Henry II.
2. 9 John.
3. 13 Henry III.
4. 6 Edward III.
5. 5 Richard II.
6. 1 Henry IV.
7. 2 & 3 Philip and Mary.
8. 2 Charles I.
9. 29 Charles II. abrogated by 3rd Wm and Mary.
10. 1 James II.
11. 3 William and Mary, abrogating 29 Charles II.
12. 7 William III.
13. 10 William III. Letters Patent.
14. 25 George II.
15. 25 George II.
16. 48 George III
17. 8 George IV.

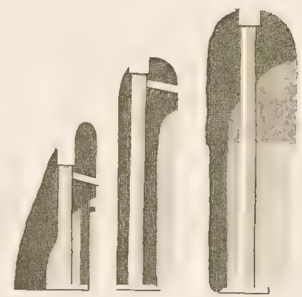
END OF DIVISION II.

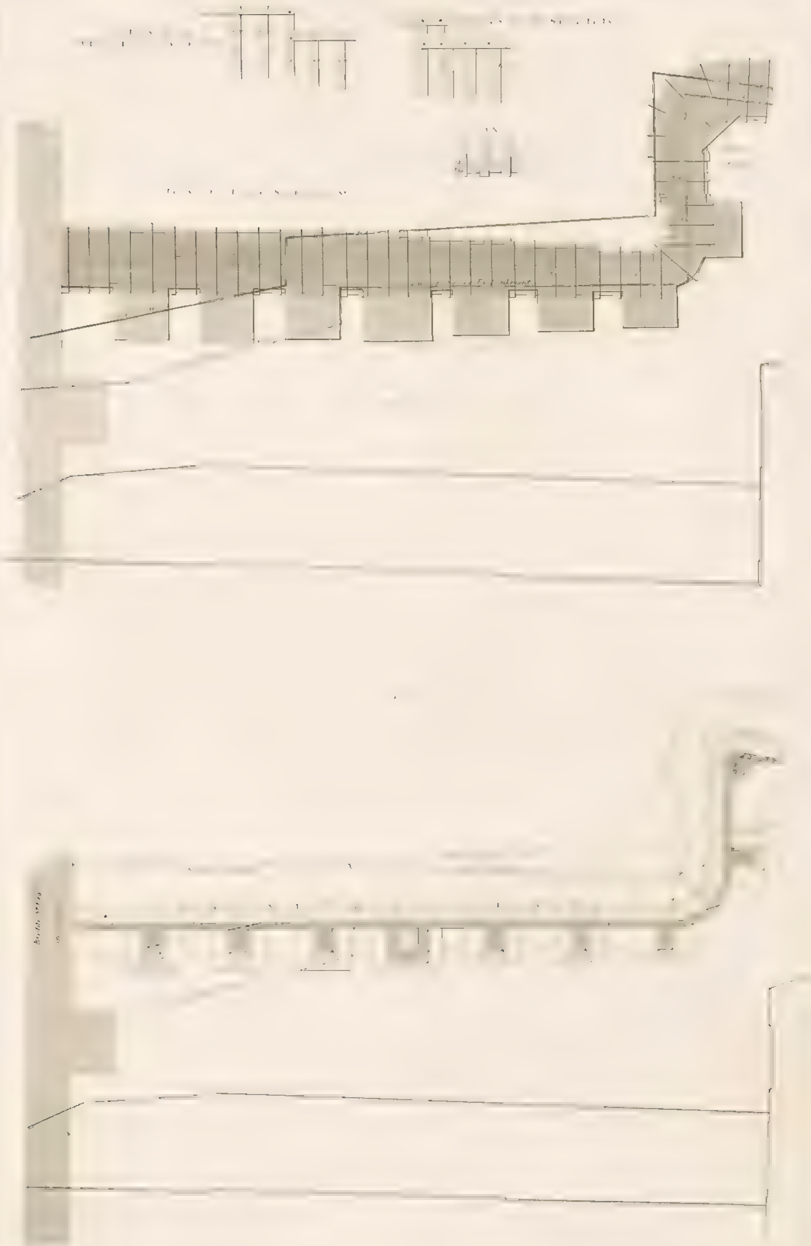
LONGITUDI

TRANSVERSE SECTION OF THE THAMES AND MEDWAY TUNNEL,

shewing the appearance at the opening, at the distance of one mile within

THAMES AND MEDWAY TUNNEL,





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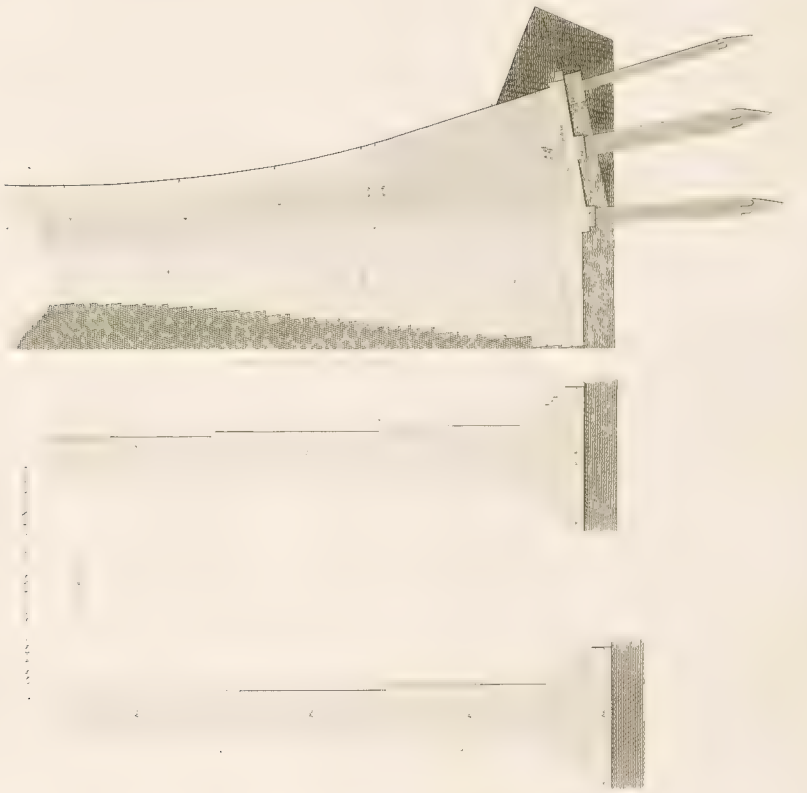
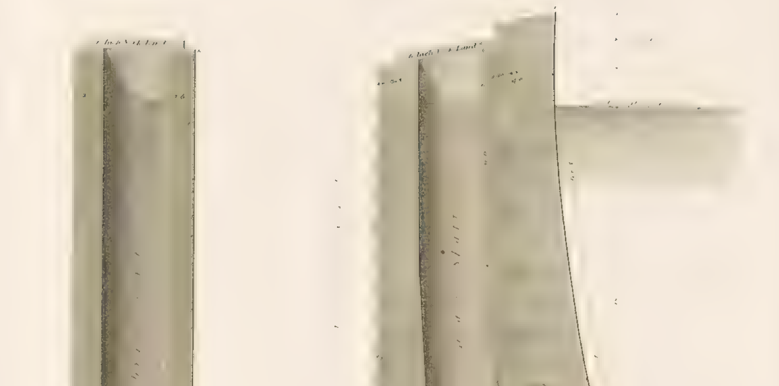
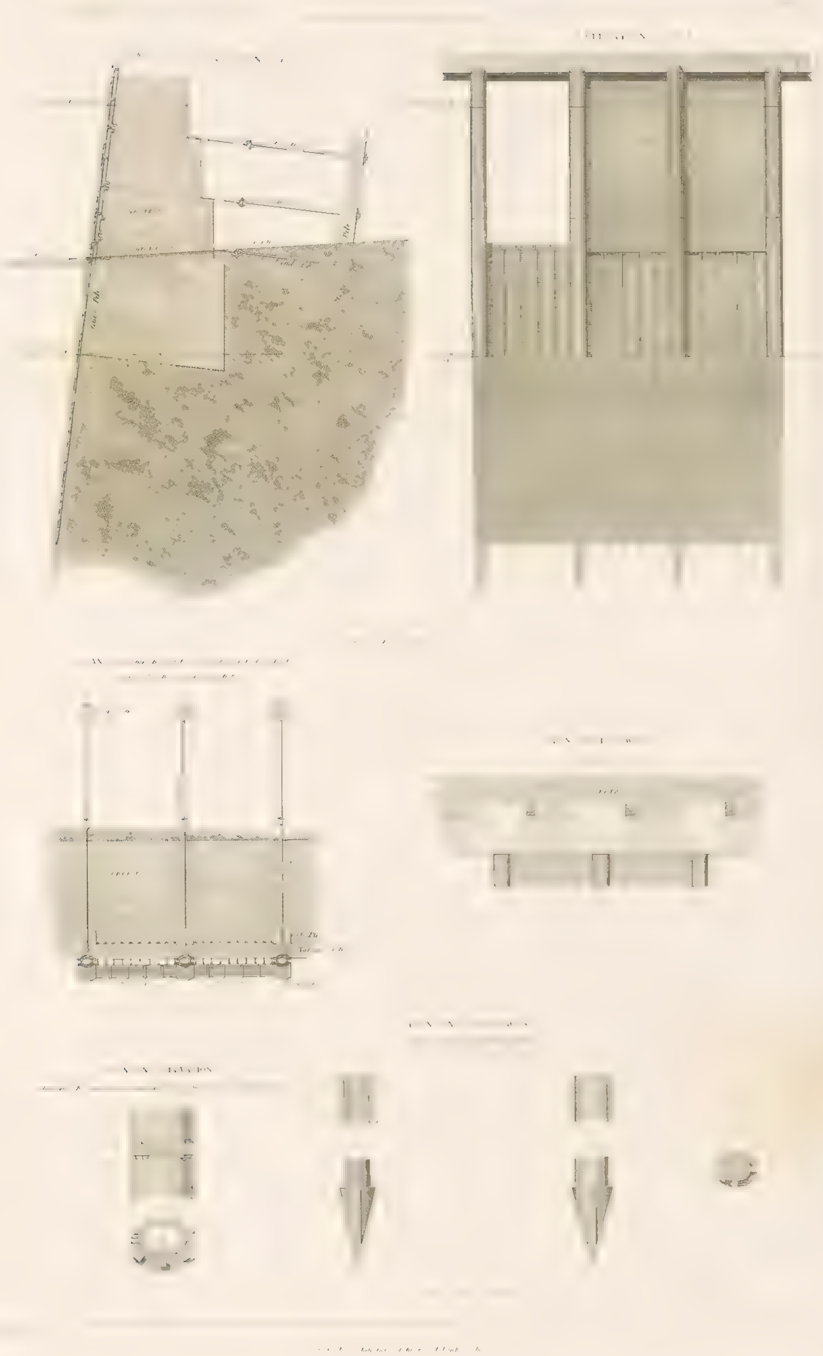
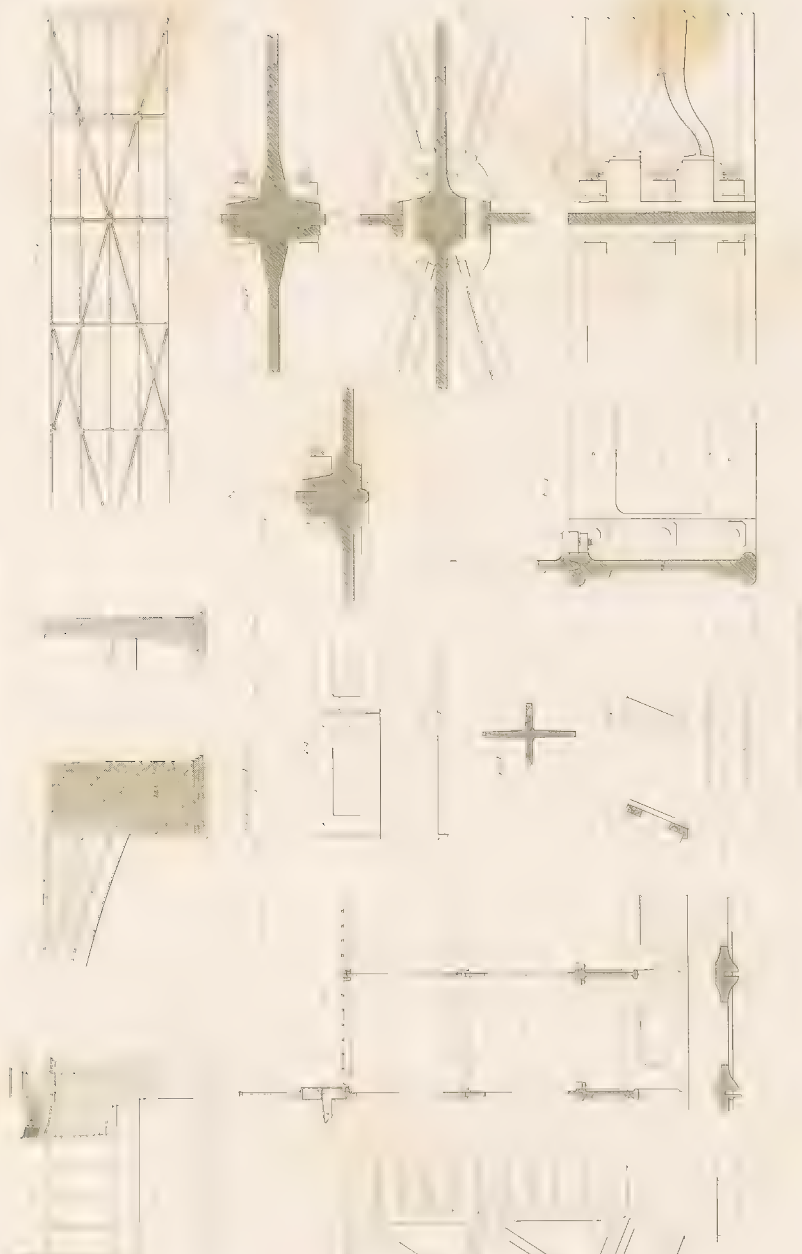
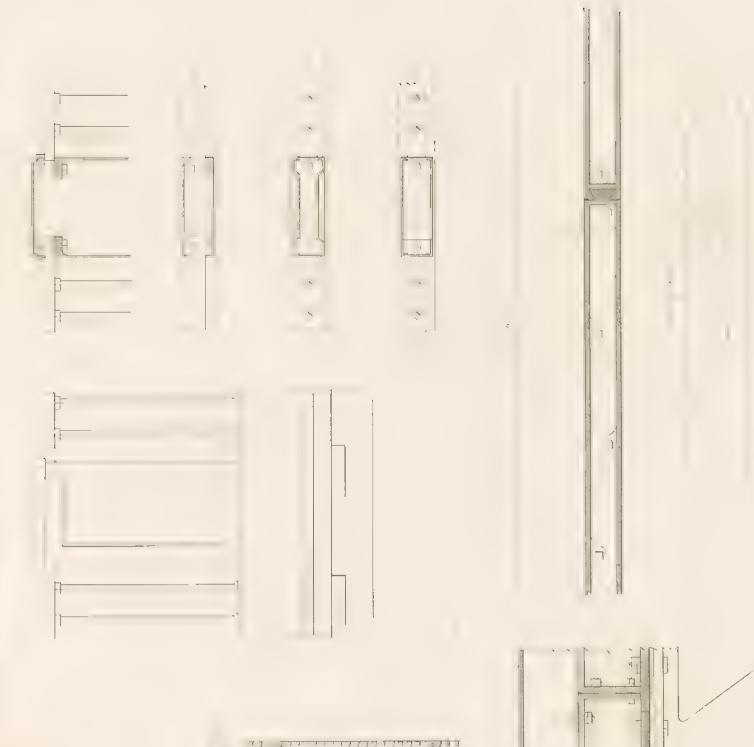
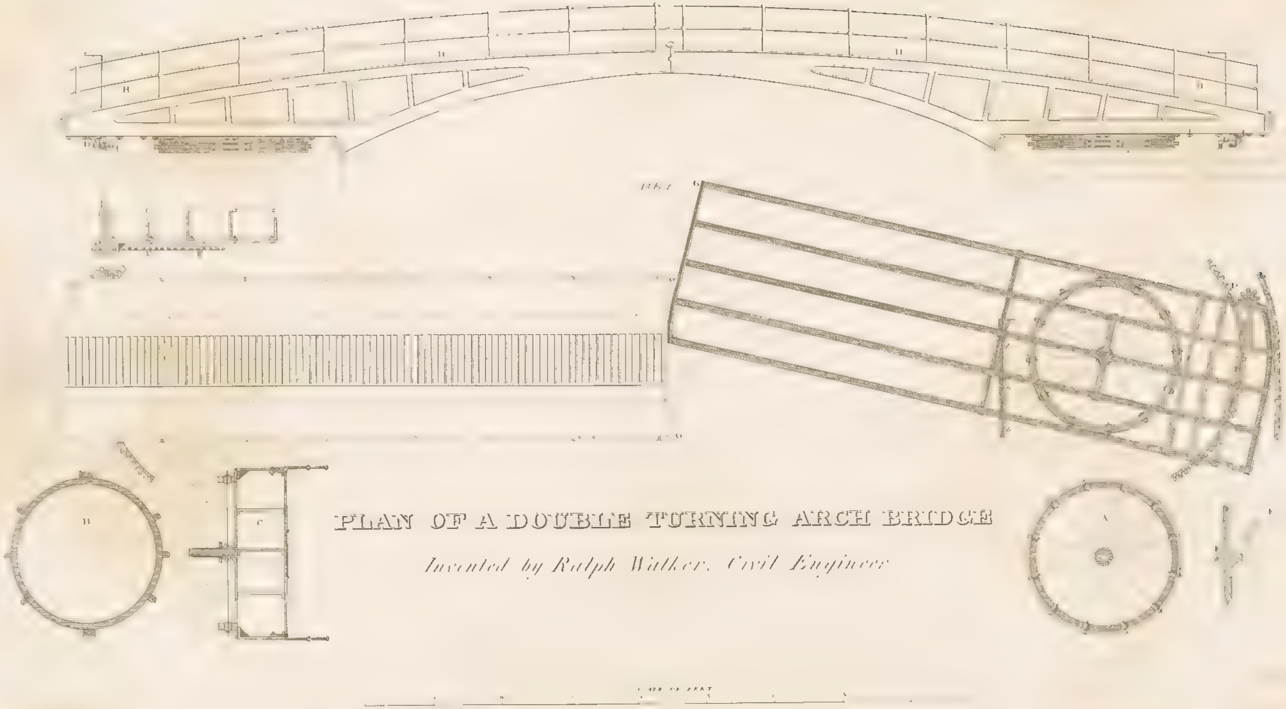



Puddle







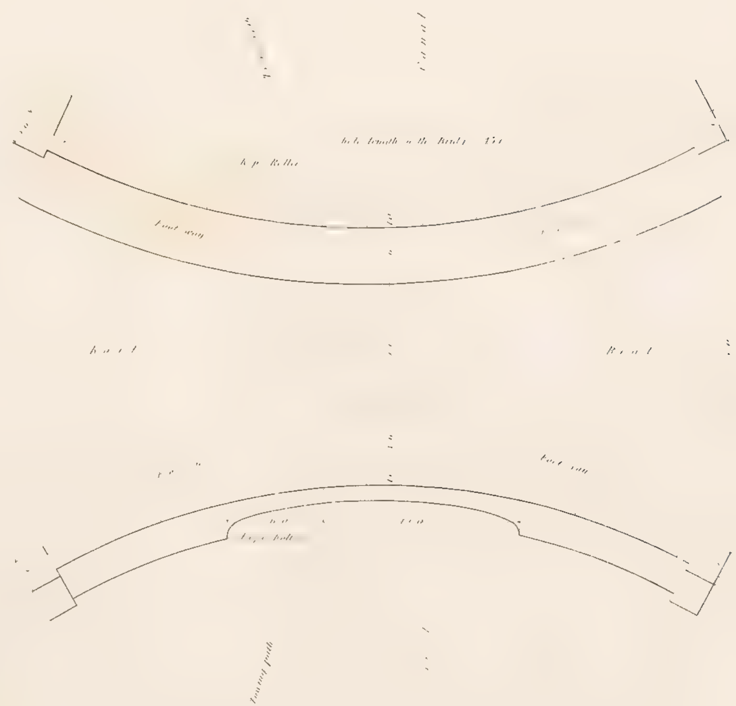


PLAN OF A DOUBLE TURNING ARCH BRIDGE

Invented by Ralph Walker, Civil Engineer

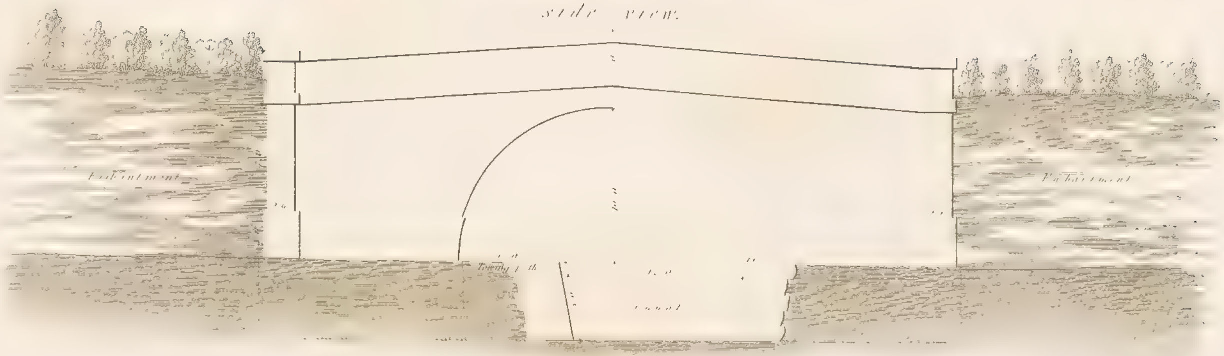
Wm. Strickland Archt. & Engr.

PLAN OF A ROAD BRIDGE.

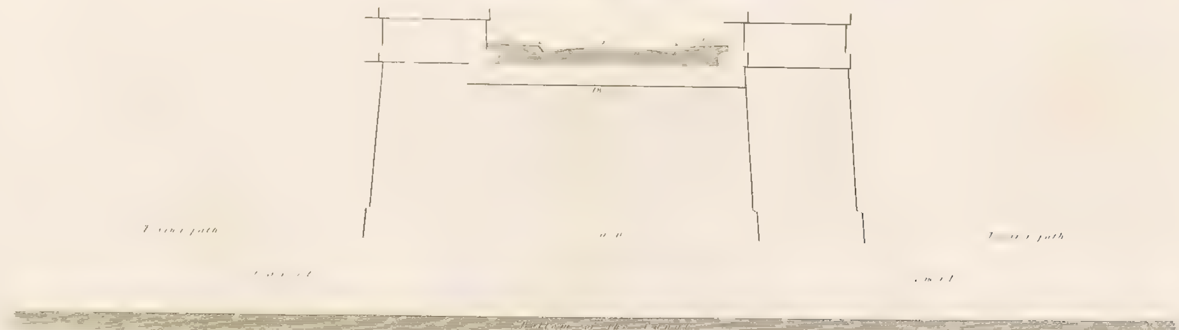


A ROAD BRIDGE,

side view.

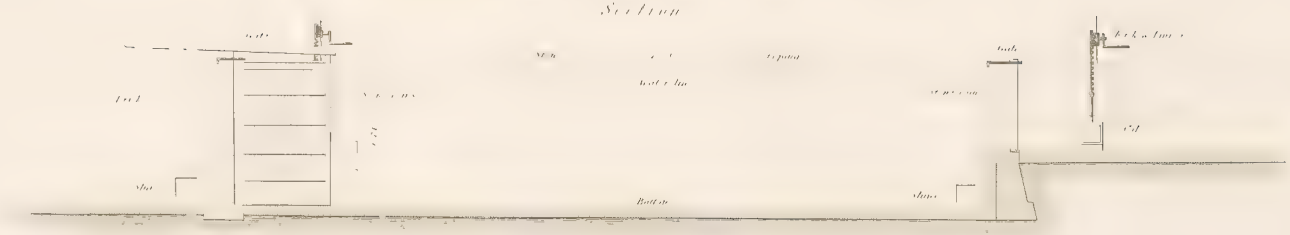


TRANSVERSE SECTION

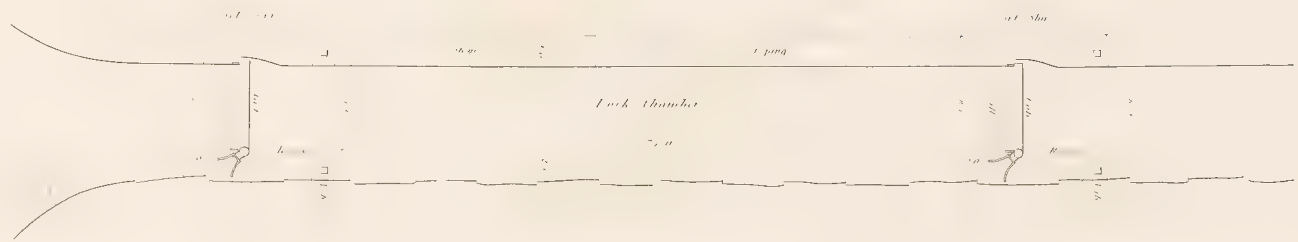


BIRMINGHAM & LIVERPOOL CANAL.

Section

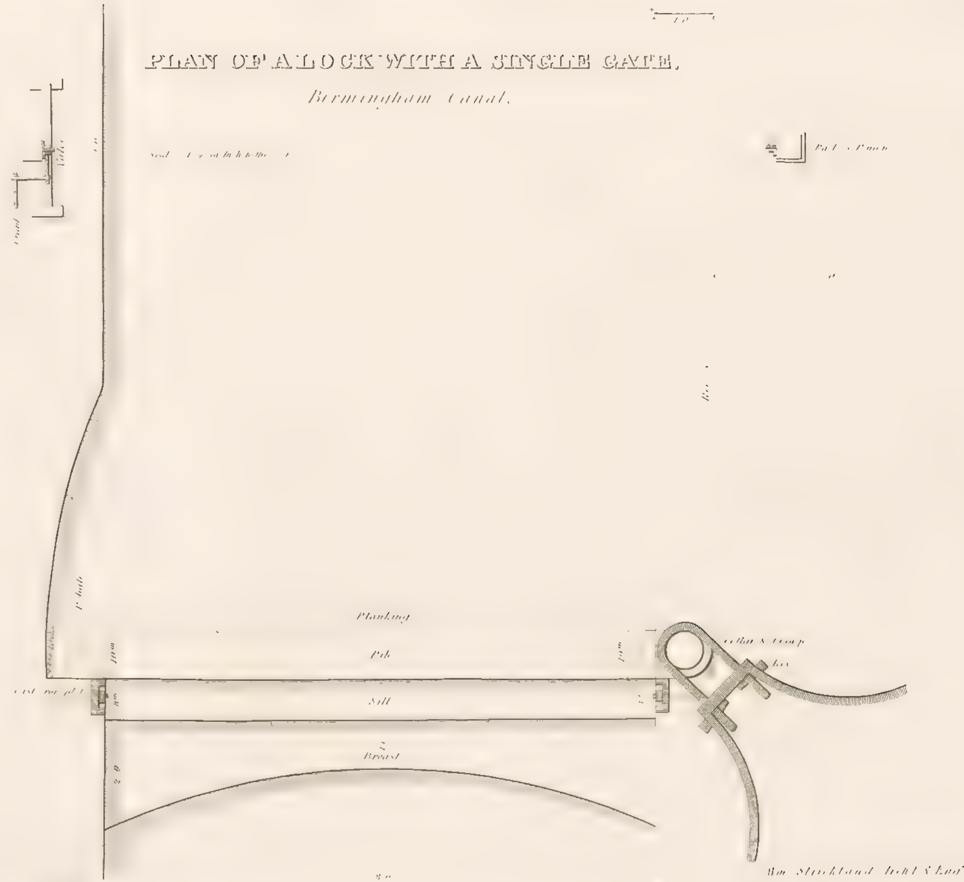


Plan



PLAN OF A LOCK WITH A SINGLE GATE,

Birmingham Canal.

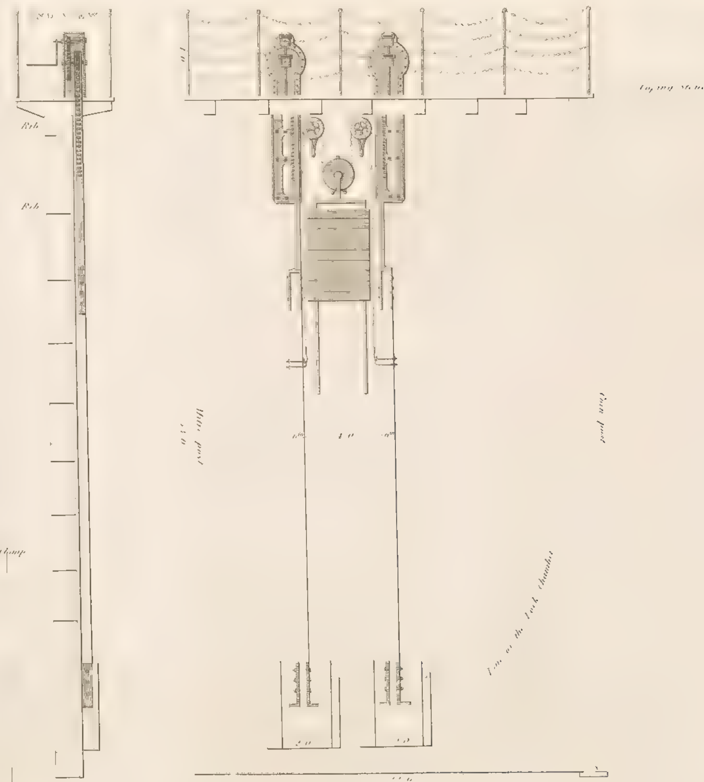


Wm Strickland Archt & Engr

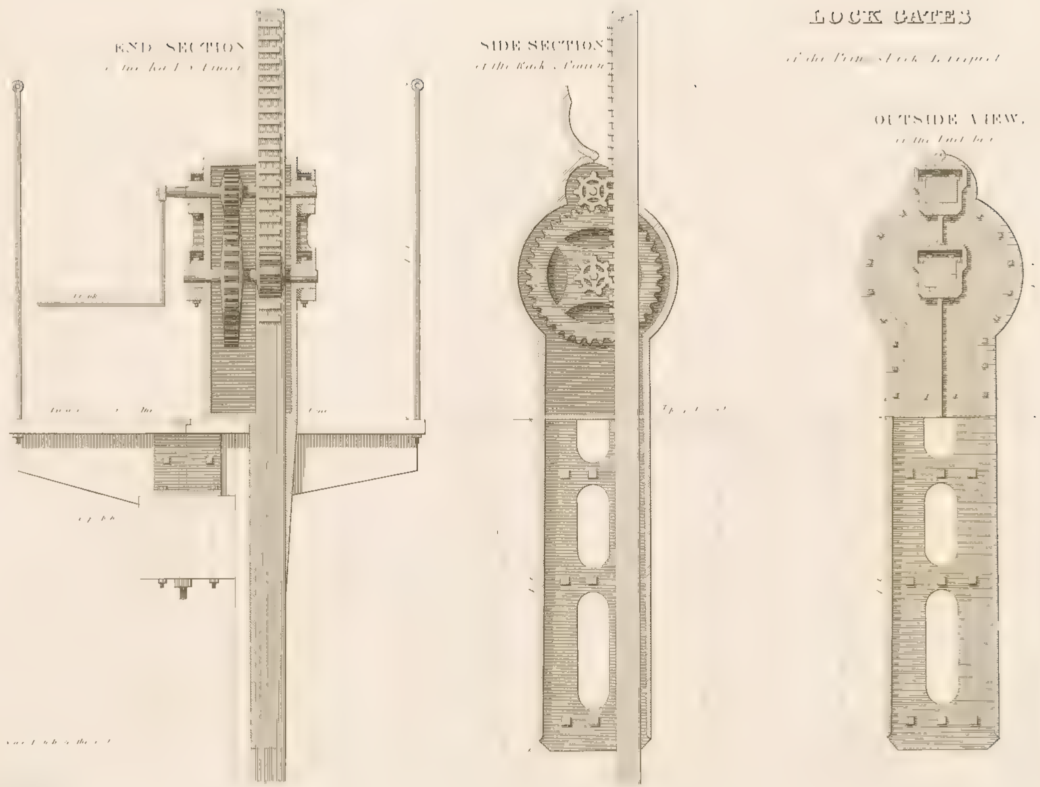
PLAN OF ONE HALF OF THE LOCK GATE.

Princes Dock Liverpool

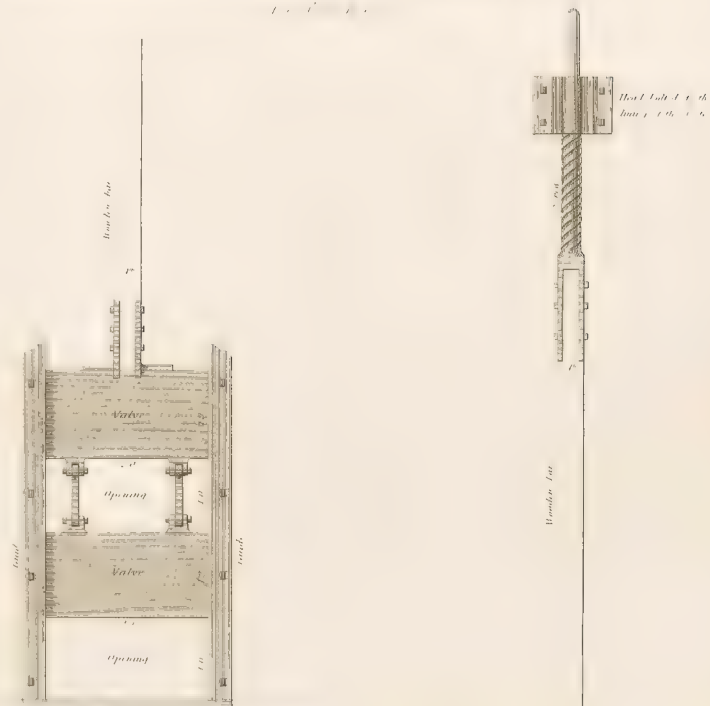
SIDE VIEW OF THE GATE VALVES, AND COUNTER WEIGHT.



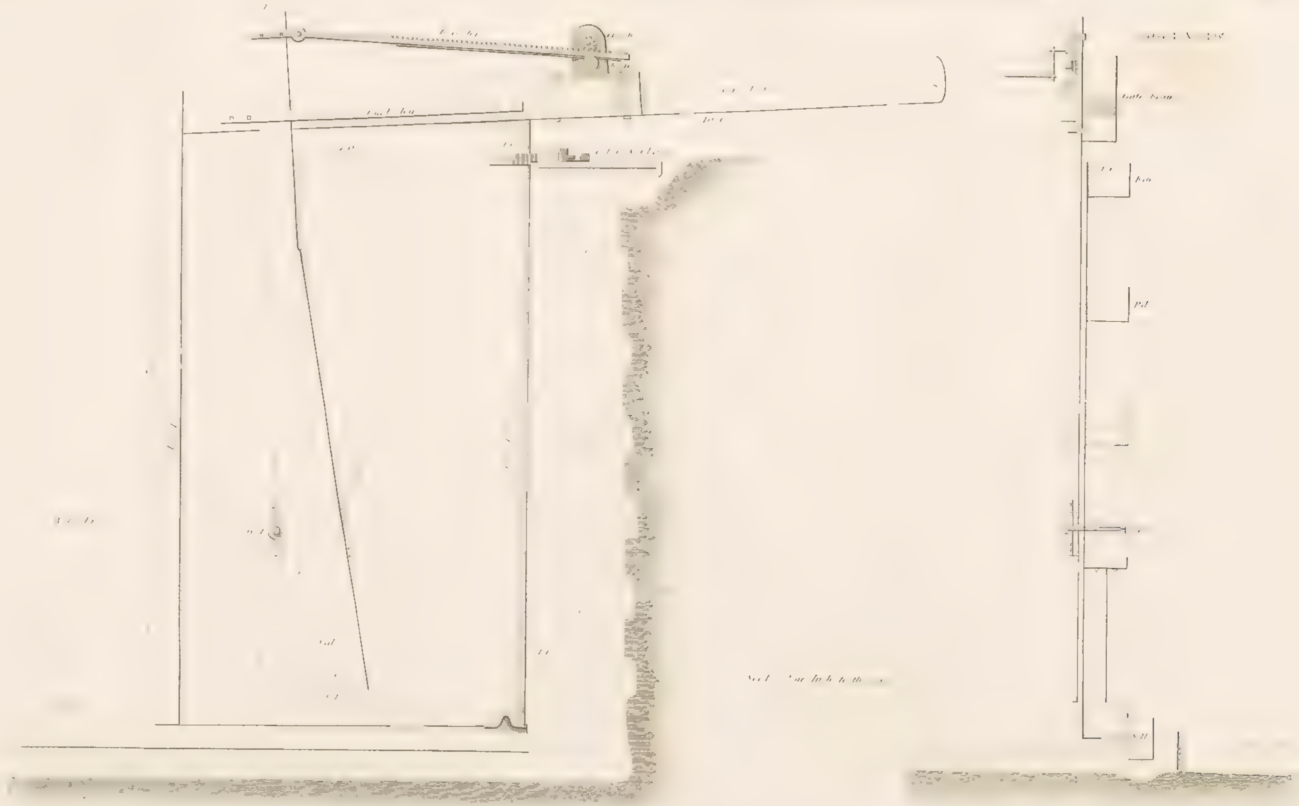
Wm Strickland Esq.


LOCK GATES
END SECTION
SIDE SECTION
OUTSIDE VIEW.

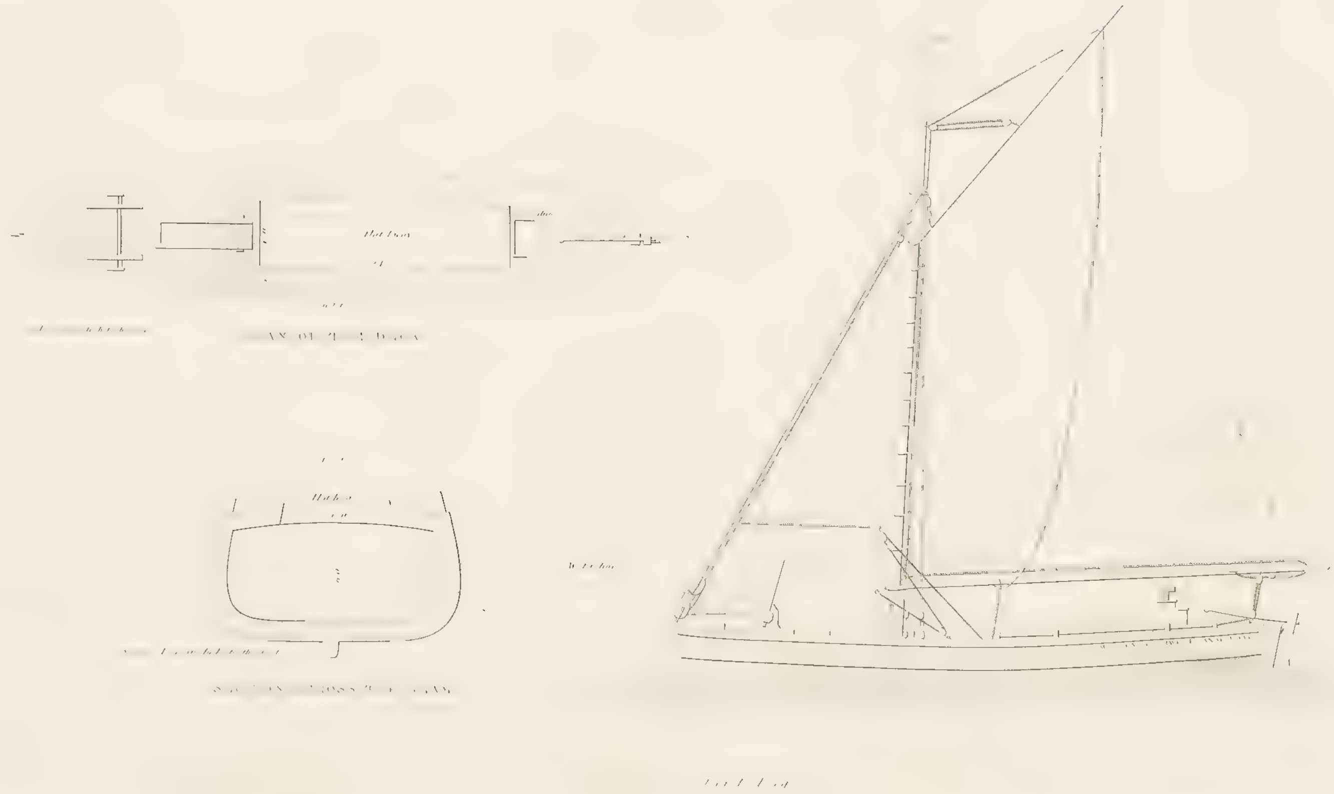
DOUBLE VALVE, WITH ONE FOOT LIFT.



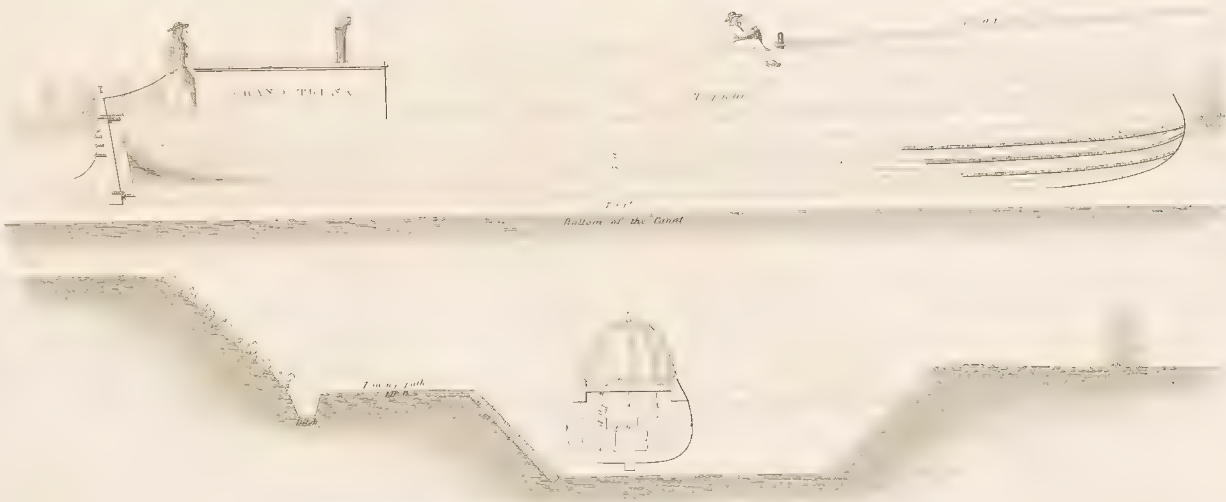
LEVER VALVE, LOCK GATES OF THE ROCHDALE CANAL.



MERSEY AND IRWELL CANAL BOATS.



BOAT USED ON THE GRAND TRUNK, AND BIRMINGHAM CANALS.



SECTION THROUGH THE CENTRE OF THE BOAT.

PUBLIC WORKS

OF

GREAT BRITAIN.

DIVISION III.

COMPRISING

TURNPIKE ROADS, IRON, STEEL, AND GAS WORKS.

TURNPIKE ROADS.

Plates CXIII. to CXVIII.

A foreigner, who for the first time makes the tour of Great Britain, cannot fail to be struck with the neatness and excellence of the roads; they are, in fact, enduring monuments of her present wealth as well as the means of its security and increase. They have not only been the means of enlarging the foreign commerce of the country, but of fostering an internal trade, which, with all the advantages attendant on foreign commerce, has perhaps far exceeded it in extent, value, and importance. So great has been the effect produced by that general spirit of road improvement which had its commencement about the middle of last century, that in many instances the appearance of the country has been entirely changed thereby.

However useful the exertions and writings of the late Mr. M'Adam may have been in calling the general attention to this subject, and by stimulating the different commissioners of the highways to make improvements, which, perhaps, might otherwise have long remained undone, it is to the late eminent Mr. Telford that we are indebted for the sound scientific principles of road making, by which our greatest public highways have been brought to so high a state of perfection and durability that we now leave far behind in that respect every other nation of the world.

The road from London to Holyhead presents the finest example of road making in the world. Under the superintendence of the Commissioners of Woods and Forests, Mr. Telford made great advances towards bringing it to perfection; and such portions as remained unimproved at the time of his decease are now in like manner being perfected by the gentlemen who have succeeded him as Engineers to the Commissioners, John Macneill and John Provis, esquires, the former gentleman taking charge of that portion of the road between London and Shrewsbury, and the latter from thence to Holyhead. Mr. Telford's principles of road making, and the method of maintaining them in a perfect state of repair, are as follow:

SHAPE, OR TRANSVERSE SECTION.

The roadway should be thirty feet broad; the centre should be six inches higher than the level of the sides, where the junction of the surface, with the sloping edge of the footpaths, or other defining bounds of the roadway, form the side channels; at four feet from the centre (on each side) the surface should be half an inch lower; at nine feet, it should be two inches lower; and at fifteen feet, its extreme edge, it should be six inches lower: this will give the form of a flat ellipse, which is well adapted for carrying off the water to the side channels, without making the cross section of the road too round, and allows the sun and wind to have a greater effect in evaporation, and keeping the road dry.

The footpaths should be six feet broad, and have an inclined surface of one inch in a yard towards the road; its surface should not be lower than the level of the centre of the road, and the edge should be sloped down (and covered with green sod) to meet the roadway, and form the side channel to carry off the water from the surface.

DRAINAGE.

All open main drains should be cut on the field side of the road fences, and should lead to the natural water-courses of the country; in general, they should be three feet deep below the bed of the road; one foot wide at bottom, and from three to four feet wide at top. Stone drains and culverts should also be made under the road, and continued to the open side drains, or ditches; side channels (before named) must be made on the road side, with openings of masonry into the cross drains, to prevent any water lying on the road: it being necessary, in order to preserve the surface of a road perfect, that it be kept completely dry. All land springs ought to be carried from the site of the road by under-draining.

FENCES.

"All road fences should be kept as low as possible, never being allowed to exceed five feet in height, in order that they may not intercept the sun and wind, and diminish their effects in producing evaporation;" and for the same reason no trees should be allowed to grow by the side of a road; for by keeping the roads wet, they occasion the rapid wear of the materials of which they are formed.

ROAD MATERIALS.

The hardest description of stone should always be preferred, such as basalt, granite, quartz, &c. The whinstones, found in different parts of the United Kingdom, Guernsey granite, Mountsorrel and Hartshill stone of Leicestershire, and the pebbles of Shropshire, Staffordshire, and Warwickshire, are among the best of the stones now commonly in use. When the materials are stone, they should be broken to a size of a cubical form, not exceeding 2½ inches in their largest dimensions, and should be capable of passing through a ring of that diameter. When it consists of gravel, the pebbles which are from 1 to 1½ inches in size only should be used for the middle part of the road; all larger pebbles should be broken; the smaller stones may be used for the sides of the roads and the footpaths.

THE FOUNDATION AND DISPOSITION OF MATERIALS.

Before the foundation is laid, the surface on which it is to rest must be prepared, by making it level from side to side, and, if necessary, raising it so that the finished surface of the road may not be below the level of the adjoining fields. If the subsoil be wet and elastic, it must be rendered non-elastic by whatever means is best adapted to overcome the cause, as drainage, &c. The foundation should consist of a rough close-set pavement, of any kind of stones that can be most readily procured; those set in the middle of the road should be 7 inches in depth; at 9 feet from the centre, 5 inches; at 12 feet from the centre, 4 inches; and at 15 feet, 3 inches. They should be set with their broadest faces downwards,

and lengthwise across the road: and no stone should be more than 5 inches broad on its face. "The irregularities of the upper part of the pavement should be broken off with the hammer, and all the interstices should be filled with stone chips, firmly wedged, or packed by hand with a light hammer; so that, when the pavement is finished, there may be a convexity of 4 inches in the breadth of 15 feet from the centre."

"The middle 18 feet of pavement should be coated with hard broken stones, of the form and size described under the head 'Road Materials,' to the depth of 6 inches. Four of these 6 inches to be first put on, and worked in by carriages and horses; care being taken to rake in the ruts until the surface becomes firm and consolidated, after which the remaining 2 inches are to be put on."

"The paved spaces on each side of the 18 middle feet should be coated with broken stones, or well cleansed strong gravel, up to the footpath, or other boundary of the road, so as to make the whole convexity of the road 6 inches from the centre to the sides of it; and the whole of the materials should be covered with a binding of an inch and a half in depth of good gravel, free from clay or earth."

The footpaths should be made with a coating of strong gravel, or small broken stones, at least six inches deep.

As a further illustration of the superiority of Mr. Telford's method of forming and repairing roads, we have given sections of the Highgate Archway Road, Plates CXIII. and CXIV., showing the manner by which it was brought, under the direction of Mr. Macneill, from the very worst state, to be one of the best portions of the mail coach road from London to Holyhead.

"The road being situated between two high banks of clay, upon a subsoil surcharged with water, it was a work of great difficulty and expense to secure a good road. The first, made by coating the old surface of the road with a thick layer of broken stones, completely failed, in consequence of the stone mixing with the wet clay, and being rapidly worn away, without forming a solid mass: this being the case, and no stone to be had for a substantial bottoming, led to the scheme of making a foundation with a mixture of Parker's cement and cleansed gravel; therefore, after bringing the road to a proper cross section, and making a sufficient number of covered drains, both in diagonal and longitudinal directions, the fifteen centre feet were covered with a layer of the before-mentioned cement concrete, six inches in thickness; the proportions used were $\frac{1}{10}$ Roman cement, $\frac{1}{10}$ sand, and $\frac{8}{10}$ stones; the sand and cement were mixed (dry) in a large shallow trough, gravel was added, as little water as possible used, and the whole mixture then cast on the ground, and before it set it was indented with triangular furrows to retain the broken stones and carry off the water; over this, when sufficiently hardened, which was in about fifteen minutes, there was laid a coating of Guernsey granite, six inches in thickness; the remaining space on each side was made up with flint gravel; the result has been the establishing a perfectly hard and smooth road, up which the heavy loaded coaches pass with great ease."

Mr. Macneill, who, as before stated, has charge of that portion of the road between London and Holyhead, is now making great improvements in various parts of the road, namely at River Hill, Dunstable Chalk Hill, also near Daventry, and at Wilhenhall hill, &c. &c. As a practical example we shall here insert one of that gentleman's specifications for the improvement of that part of the road which is called Geese Bridge Valley;* this improvement consists in lowering of the hills, and filling up the valley to a certain height, and, to assist the motion of carriages up the hill when completed, he is laying stone blocks or trams for the wheels to roll upon, which will be more fully understood from the following specification, and Plate CXV. to which it refers.

* Called by mistake on the plate "Cheese Bridge Valley."

DUNCHURCH AND STRATFORD TRUST.

Plate CXV.

Specification for the Improvement of Geese Bridge Valley, on the said Trust :—

This work commences nearly opposite the sixty-sixth milestone, and terminates near Foster's Booth. It is to consist of lowering the hills, filling the hollow at the Bridge, and laying down cut-stone trams on one side of the Road; and forming and regulating the surface throughout to one uniform and regular plan, as will be hereafter described.

The black curving line on the section represents the present surface of the road; the red line on the said section represents the finished longitudinal surface of the foundation for the road materials; the red figures denote the depth of cuttings and heights of embankments; and it is expressly stipulated that the Contractor is to satisfy himself by his own admeasurement, or in any way he may think proper, as to those heights and depths, or any irregularities of other parts of the surface of the ground to be cut down or embanked, as no future extra claim on any pretence whatever will be admitted. The breadth of the finished carriage road is to be thirty feet in all cases; and the surface on which the hard materials are to be laid, is to be formed level from side to side. The slopes of the embankment from the outside of the finished Road are to be two horizontal to one perpendicular.

In the cuttings, the surface lines of the side slopes are to commence behind the mounds raised for the quicks, and are to be forty feet apart; that on the southern side is to be three horizontal to one perpendicular, and that on the northern side two horizontal to one perpendicular. All the embankments are to be sloped at the rate of two horizontal to one perpendicular; and the slopes of both cuttings and embankments are to be neatly formed, and soiled over with good mould, at least 2½ inches deep, and sown with grass-seeds. Along the outside of the carriage way, on the embankment, and through the cuttings, drains are to be cut, twelve inches wide at bottom, fourteen inches wide at top, and fourteen inches deep below the bottom of the pavement, or lower course of stone. In the bottom of these, open brick drains are to be laid; these openings are to be four inches wide and four inches high; the remaining space to be filled up with rubble stone, or large pebbles free from clay or mould. Cross drains are to be made from the middle of the Road into these side drains, forming such angles in the said middle as may be necessary to give declivity for carrying the water into both the side drains; they are to be nine inches wide at bottom, twelve inches wide at top, and ten deep, as shewn in the drawings. At the rate of thirty of these drains to be made per mile: and through the cuttings there are to be sixty per mile. These cross drains are to be filled with rubble draining stones, to connect with the bottom pavement, and laid in quite clear and free from sand or earth. Should spring water rise into these drains, a covered conductor, four inches square, as already described, is to be made from them; and in this case the bottom is to be twelve inches wide, to admit the two bricks on bed, with an opening of four inches between them; the bricks are to be neatly and firmly laid, with a brick laid lengthwise across, and are to be carefully packed and secured by rubble stones up to the top.

ROAD MAKING.

When the new portion of the work is brought to a perfect cross level and uniform surface, the Road-making is to be commenced. A bottom course or layer of the best limestone is to be set by hand, in form of a close, firm pavement: the depth is to be seven inches in the middle of the road; at nine feet from the centre, five inches; at twelve feet from the centre, four inches; and at fifteen feet, three inches; except where the stone trams are to be laid down, as hereafter described. They are to be set on their broadest edges lengthwise across the Road, and the breadth of the upper edge is not to exceed four inches in any case. All the irregularities of the upper part of the said pavement are to be broken off by

the hammer, and all the interstices to be filled with stone chips, firmly wedged or packed by hand with a light hammer; so that when the whole pavement is finished, there shall be a convexity of four inches in the breadth of fifteen feet from the centre. When this part of the work is completed, it is to be approved of by the Engineer before any of the second coating is laid on: this is to consist of the best limestone of the neighbourhood; it is to be cleansed from clay or sand, and every stone exceeding two inches in size is to be broken: this coating is to be laid on three inches thick from side to side, and carefully raked every day, so as to remove every appearance of cart tracks. When this coating is laid on, the side drains are to be formed, and the bricks laid in, and the sod borders completed, and finished up. When this is done, and examined by the Engineer, then the third coat is to be put on, which is to consist of the best Hartshill stone, four inches thick in the middle, and three inches at ten feet from the centre; the sides or shoulders are then to be made up with the best limestone, broken so that no piece shall exceed two inches in its largest dimensions; the thickness of this side coating is to be four inches at ten feet from the centre of the Road, and three inches at the sides or fifteen feet from the centre, except where the trams are to be laid down; and the whole surface is to be formed uniform in every part, the channels to be precisely on the same level, and six inches below the level of the centre of the Road.

On the steep parts of the Road, as shewn on the section, from the letter A to the letter B on the east side of the valley, and from C to D on the west side, two lines of stone blocks are to be laid down, to form a tram or track for the wheels of carriages. These blocks are to be of granite from the quarries at Mount Sorrel; they are to be twelve inches deep, fourteen inches broad, and not less than four feet long: they are to be pricked on each face, the upper surface to be parallel to the bed, and the sides and ends dressed square, and pricked in the same manner as the specimen now lying at Stow Hill Wharf, near Weeden, for the inspection of those who may propose for the work. The foundation for these blocks is to be prepared in the following manner, as shewn in the drawing.—The ground is to be excavated to the proper depth to receive the different materials hereafter described, so that the upper surface of the stone blocks will be on a level with the carriage-way when finished; the width of this opening is to be eight feet, extending from the channel towards the centre of the Road. When the bottom is properly and evenly levelled, a pavement of limestone, or good sandstone, from the quarries near Stow, is to be laid by hand in a similar manner to that above described for the road work; these stones are to be eight inches deep throughout, to be firmly packed and perfectly level from side to side. When the interstices are filled up with stone chips, and the whole firmly packed, good lime grout is to be poured into the joints; one barrel of lime, and two barrels of sand and gravel, properly mixed and used whilst fresh, are to be used on every lineal yard: this work is to be done to the satisfaction of the Engineer, and every care taken to render it solid and substantial in every respect. On this pavement three inches of broken stone from Lovels or Stow quarries are to be laid; no stone is to exceed $1\frac{1}{2}$ inches in its largest dimensions; they are to be put on after the foundation course has been inspected and approved by the Engineer, and not before. On this layer of stone two inches of the best gravel is to be laid; it is to be rolled with a metal roller several times, so as to consolidate the stone and gravel together, and render it one firm mass. On this gravel the stone blocks or trams are to be laid; they must be even on the bed, and the ends must abut together and form one continuous and uniform line; the surface of each must be on the same level, and perfectly uniform with the blocks on the opposite side, that is to say, the surface of each line must be perfectly level, and correspond throughout. When the trams or blocks are laid to the satisfaction of the Engineer, the space below them, and the space on the outside, is to be filled up to within six inches of the upper surface with broken limestone, no piece of which shall exceed $1\frac{1}{2}$ inches in its largest dimensions; a row of paving stones of granite, not less than six inches deep, five inches wide, and nine inches long, is to be placed on each side of the trams or blocks; these stones to be of the best granite from Mount Sorrel quarries; they are to be dressed in the same manner as the stones called Sovereign in the London market; these paving stones are to be placed close to each side of the blocks, and firmly packed up with Hartshill stone, broken, not to exceed two inches in its largest dimensions, for the first three inches, the next three inches towards the surface to be broken to $1\frac{1}{2}$ inch in its largest dimensions. When this work is completed, the whole is to have a top dressing of one inch of good gravel, evenly spread and rolled twice in wet weather. The side of the Road next the trams is to be formed and dressed so as to come on the same level; and when the whole is finished, to form one

uniform surface of carriage-way, as shewn on the Plan. A drain eight inches deep, and four inches wide, is to be formed on each side of the trams, the bottom of which is to be eight inches below the bottom course of the pavement, and is to be formed of rubble stone or bricks, so as to lead off any under or surface water that might otherwise injure the foundation or bed of the trams. These drains are to have off-lets into the large side drains, which are to be two feet under the surface of the roadway, where the trams are to be used; and, should it be thought necessary, wells or upright shafts must be constructed at every one hundred yards apart through the cuttings, to let the surface water into the under drains without running along the surface. The tops of these wells are to have an iron grate one foot square, the bars of which are to be two inches deep, 1½ inch apart, and one inch wide, set in proper frames.

The estimate or proposal for this part of the work must be given in detail by the running yard, as well as for the whole work, as it may not be executed, or only in part, and the Commissioners are to have the power to dispense with it altogether or in part, or execute more than herein specified, should they think proper.

All that part of the Road between the extreme points which is not cut down or filled, is to be brought to an uniform and regular surface, as before described, and covered with three inches of Hartshill stone from side to side, where the trams or blocks are to be laid down; the surface, after being properly formed and dressed, is to be also coated with broken Hartshill stone four inches thick, laid on in two coats at different times, as may be pointed out by the Engineer; the side next the trams to be broken to a size of 1½ inch for three feet wide, and covered with an inch of stone gravel from the Hartshill quarries.

MASONRY.

A new culvert is to be built over the stream in the lowest part of the valley, according to the Plan No. 2. (Plate CXV.)

The ground is to be excavated to the depth of six feet for the foundation, if necessary, to procure a solid and uniform bearing for the abutments and pier. The foundation of the abutment, pier, and wing walls to be of good limestone to the surface of the ground, the abutments to be three feet thick, the pier three feet thick, and the wings two feet three inches at the level of the ground, increasing by three inch offsets at every eighteen inches to the bottom course. The abutments and pier to be of the best brick masonry, laid header and stretcher in lean joints, and with mortar composed of the best lime, mixed with two parts of clean sharp sand, and used whilst fresh.

The arches are to be eight feet span, rising four feet, to be built of the best brick, and such as approved of by the Engineer; they are to be one foot two inches thick at the springing, and the same all the way up to the crown. The headers of the arches to shew fourteen inches all round. The arches are to be turned on a centre constructed of good square timber, and approved of by the Engineer.

The backing of the abutments and arch is to be of good stone masonry one foot ten inches thick at the springing of the arch; at the height of two feet above the top of the abutments there is to be an offset of one foot; at the height of two feet there is to be another of six inches; and at the height of four feet to slope to the back of the arch. The water wing walls are to be six feet long; they are to be founded at the depth of six feet below the ground line, and to be built of stone masonry four feet thick at the bottom, and diminishing by an offset of six inches to the height of three feet, and to continue of that thickness to the top. They are to rise to the ground line, and to be coped with sod; the splay to be three feet in each, or to be twenty-five feet in the clear at the extremities.

The spandril and wing-walls above the ground line are to be of the best brick masonry, to be 3 feet thick, with 9 inch counterforts, founded on the stone masonry before described; at the height of 5 feet, there is to be an offset of 3 inches, and the remaining thickness of 2 feet 9 inches to be

continued to the road line. There is to be a string course of free stone 5 inches thick, 1 foot on the bed, and projecting 2 inches over the face of the work; the under edge to be 1 foot 6 inches above the upper line of the arch at the crown. A parapet wall is to be built over the arch, to be 14 inches thick and 2 feet high, and coped with stone, 6 inches thick in the centre, and 4½ inches at the sides, which are to be flush with the brickwork.

The wing-walls are to be coped with good green sod, and the slopes dressed down to them in a smooth and uniform surface. The whole of the works and the materials to be approved of by the Engineer. All the face work to be laid in mortar, composed of two parts of lime to one of sharp sand. (The bricks in the old culvert to be carefully cleaned and allowed for by the Contractor if they can be used in the new work or side drains.) There is to be an invert 1 foot thick, dipping 6 inches in the centre, placed under each arch, and extending 6 feet beyond the end of the piers; it is to be of good stone, laid in carefully, and firmly packed, the ends to be secured with timber sills, 6 inches by 12, secured in a proper and substantial manner by piles driven into the ground at every 4 feet across the stream.

FOOTPATH.

A footpath is to be formed on the north side of the road; it is to be 6 feet wide when finished, and 6 inches above the level of the road channel; the surface is to be formed smooth and level, with a declivity from the carriage-way of 2 inches; it is to be coated with 3 inches of good gravel, and to be faced with green sod, evenly laid and neatly jointed: a drain, 10 inches deep, and 10 inches wide, is to be formed along the inside of the footpath at the bottom of the slopes through the cuttings; it is to be filled with rubble stones, and, should springs occur, with an open tile: cross drains are to be made under the footway at every 100 yards; they are to be formed of draining tiles. Where the trams are laid, the footpath is to be faced with stone.

DRAINAGE.

No culvert will be required on this work, except the one before specified, but should it be found that any springs arise when the cuttings are made, there must be barrel drains of brick or rubble stones, constructed of such dimensions as may be fixed on by the Engineer, and the price is to agreed upon before executing the work, and allowed for, as an extra charge beyond the amount named in the contract.

SIDE ROADS.

The road leading to Northampton above the osier bed is to be lowered, so that the acclivity into it from the road shall not exceed 1 in 20; it is to be formed level from side to side, and covered with gravel or broken limestone 8 inches thick. Three field roads will be required: they are to be made in such places as may be pointed out by the owners or occupiers of the fields; they are to be 12 feet wide, and formed with an acclivity not exceeding 1 in 15. They are to be coated with broken limestone 4 inches thick; and to have gates, ground posts, and iron fastenings, similar to the best descriptions used in the country. The approach to Lovel's House is to be formed from the new road with an acclivity not exceeding 1 in 15, and to be coated with gravel. Should more side roads or farm roads be required, they are to be allowed for over and above the contract; but before they are executed the price must be ascertained and approved of by the Engineer.

WATCHING AND FENCING THE ROAD WHILE IN PROGRESS.

The excavation is to be made on one side of the road, leaving a sufficient space of the present surface for carriages to travel over it. A rail fence is to be erected on the side to protect travellers during the operation of the work: it is to be firmly placed, and coloured white with lime wash. The surface of that portion of the road on which the travelling is to be continued until the first half is cut, is to be kept in a perfect state, and every precaution used for the safety of the public during the

operation of the work. A sufficient number of lights are to be kept burning, and a watchman is to be kept constantly on the ground between sunset and sunrise.

HOLYHEAD ROAD, RIVER HILL IMPROVEMENT, HERTFORDSHIRE.

The following is the specification of the work now in progress of execution for the improvement of River Hill, Hertfordshire. And as the stone pavement foundation is here dispensed with, the method of executing the work under such circumstances may be understood.

Specification of the works proposed to be executed on the Dunstable Trust, near River Hill :—

This work consists in the formation of a Road of 2,200 yards in length, to avoid the above-named Hill. It is to commence near Fly's Wash, and running along the low lands to the south-west of the present road, it crosses the two lanes leading to Flamstead, and joins the present road at the culvert near the lane leading to Windmill Hill, as shewn on the plan to which this specification refers.

ROAD MAKING.

The black line on the section represents the natural surface of the ground, on the longitudinal direction of the new line, about the middle of the space to be occupied by the new Road. The red line represents the finished longitudinal surface of the foundation for the road materials. The red figures denote the depths of cuttings and heights of embankments, and the rates of inclinations, which are as follows — level, 1 in 166, and 1 in 129. And it is expressly stipulated that the Contractor is to satisfy himself by his own admeasurement, or in any way he may think proper, as to the heights or depths, or any other irregularities of other parts of the surface of the ground, to be cut down or embanked, as no future extra claim, on any pretence whatever, will be admitted. The breadth of the finished Road is to be thirty-six feet in all cases, that is, thirty feet for the carriage-way, and six feet for the footpath. The slopes of all embankments, from the outside of the quick borders, are to be two feet horizontal to one perpendicular, neatly dressed and covered with green sod at least four inches thick, evenly laid and closely bonded.*

In the cuttings, the surface lines of the side slopes are to be three horizontal to one perpendicular on the southern side, and two horizontal to one perpendicular on the northern side. All the slopes of both cuttings and embankments are to be neatly formed, and are to be covered with sod evenly laid, and properly jointed, with the green side placed uppermost:* it must be procured from the space to be occupied by the new Road and its slopes, or from any other place the Contractor may find more convenient. The surface of the foundation for the materials of the carriage-road is to be formed level from side to side, and the breadth between the bottom of the side slopes in the cuttings at that level is to be thirty-three feet. The surface of the foundation for the hard materials of the footpath is also to be level, and to be six inches above that of the carriage-road. Along each side of the carriage-way, in all embankments, drains are to be formed: they are to be sixteen inches deep, ten inches wide at bottom, fourteen inches wide at top, and to have an open half-round tile placed on a flat one, laid along the bottom, in such places as may be pointed out by the Engineer, or by the Inspector whom he may appoint, and the space filled up with rubble stone, carefully cleansed from sand or clay. Through all the cuttings, these drains are to be sixteen inches deep, twelve inches wide at bottom, fourteen inches wide at top, and to have an open brick drain laid at the bottom, to be formed of bricks laid flat on each side, and covered with bricks laid across. The space round these bricks, and up to the level of the road, is to be filled with rubble stone as above described. Openings are to be made in these drains at every one hundred yards in the cutting; these openings

* Or soiled over, three inches thick, and sown with grass seeds.

to be of brick laid in the best mortar, and to be covered with an iron grate twelve inches square; the bars to be one inch wide, two inches deep, and one inch apart from each other. At the end of the cuttings, off-lets are to be constructed to carry away the water from these drains to the side ditches or water channels to be formed along the outside of the Road; these off-lets to be of brick masonry laid in the best mortar, and to be placed at least eighteen inches under the surface of the ground; the lower ends to be protected by a timber frame, consisting of two uprights of oak, and one transverse piece framed into the uprights; these pieces of oak to be four inches square, and the uprights to be placed eighteen inches in the ground. Similar off-lets are to be constructed on the sides of the embankments at every two hundred yards; and openings are to be formed on the sides of the Road in the embankments; these openings are to be covered with iron grates as before described in the cuttings; the off-lets are to be laid down to the outside ditches or water channels, and their lower ends are to be protected, as above described, with oak frames.

Cross drains are to be made from the middle of the Road into the side drains; they are to be twelve inches deep, ten inches wide at bottom, and fourteen inches wide at top, and to be so cut as to allow the bottom to have a regular fall from the centre towards the sides of three inches: these drains are to be filled up with rubble stone as before described. Should the ground in any part be found to be very wet, or springs arise in it, these drains must be laid with one open tile, as before described; their outer ends are to communicate with the side drains before described: these drains are to run directly across the Road, or to take an oblique direction, in the form of a V, as the slope of the ground will point out. There are to be ninety of these cross drains, and they are to be placed in such situations as the Engineer or Inspector may point out. When these drains are finished, and the surface of the ground evenly formed from side to side, and that the Engineer or Inspector is satisfied that the embankments are properly consolidated, the first coating of gravel or small flints is to be laid on; this coating is to be four inches thick; the gravel or small flints of which it is to be composed need not be cleansed; it is to be put on regularly, from the end or ends of the new line, and evenly spread, and constantly raked, so as to fill up all the cart tracks made by carrying on the gravel and other materials, for the drains, &c. When this first coating is tolerably well consolidated, of which the Engineer is to be the judge, the filling up of the side drains before described is then to be commenced; they are to be open cut only at first, and to remain so until the first coating of the Road is consolidated, and then they are to be filled up with brick, tiles, and rubble, as already mentioned. When this work is completed, the second course is to be laid on; it is to be four inches thick from side to side, as before described; it is to be laid on by commencing at the ends, and working regularly towards the centre; the ruts are to be raked in twice every day, or oftener if necessary, so that no appearance of cart track shall be left at the end of the day's work. When this coating is completed, the mounds for receiving the quick border and the sod edgings, as will be hereafter described, are to be commenced, and the Road kept constantly raked in during the progress of the work. At this stage of the work, a drain is to be opened, one foot ten inches square, along the inner side of the footpath in all cuttings, and to be filled with large flint; cross drains of a similar description are to be made from this drain to communicate with the channel drain, as before described: one of these to be made at every one hundred feet. When this is done, the footpath is to be neatly levelled, and covered with four inches of gravel evenly spread; and when the last coating is put on the carriage-way, it is to have another coating of two inches of small flints, and one inch of gravel: the surface, when finished, to be perfectly smooth, and to have an inclination of two inches towards the inner side, the outer edge to be six inches above the water channel, and neatly faced with good green sod. When the second coating is consolidated, and approved of by the Engineer, the third coating is to be put on: it is to be composed of the best flint, carefully cleansed and broken, not to exceed two inches in any of its dimensions; it is to be laid on four inches thick in the middle, diminishing to two at the sides; and the Contractor is to be accountable that the ruts or cart tracks are carefully raked in from time to time, so that the surface will be left perfectly smooth from side to side, with a fall from the centre to the sides of four inches; and the side channels are to be, when thus finished, precisely on the same level.

FENCING.

The fencing is to be constructed through the cuttings in the following manner. A trench two feet wide and twelve inches deep, reckoning from the level of the top of the footway, is to be cut on each side at the bottom of the slopes; this trench is to be filled with the best vegetable mould. Over this trench a mound of vegetable mould is to be raised; it is to rise one foot above the top level of the footway, to be three feet wide at the base and two feet wide at the top, and to have a green sod facing, six inches high, on each side. Two rows of quicksets are to be planted in the centre of these mounds; nine plants are to be set in each lineal yard; they are to have good roots, to be two years transplanted, and put in during the month of November; the distance between the middle of the rows to be forty feet. On all embankments there is to be a mound raised for the reception of the quicksets; these mounds are to be three feet wide at the base, two feet wide at top, and the height to be one foot above the level of the top of the footpath; each face of these mounds is to have a green sod border six inches high, neatly formed, and evenly laid. If the soil of which the embankment is composed be not favourable for the growth of quicks, then a trench is to be cut under the mounds, of the same dimensions as those described through the cuttings, and filled with good vegetable mould before the mounds are raised over them. The quicksets are to be protected by two rows of post and rail fences on each side of the road; there are to be three rails in each length on the road side, and two on the field side; the posts are to be five feet long, and at least five inches by three, of good oak, or elm, or ash; the rails are not to be more than eight feet long and 3½ by two inches, and may be of good beech, elm, or oak, or fir timber; in each length of rail there is to be a centre post driven into the ground; they are to be placed in the middle between the posts, and are to be at least twelve inches in the ground, and well fitted and strongly nailed to each rail. The rails may be spiked to the posts instead of mortising them, if the Contractor prefers that method, but one uniform plan must be pursued throughout the whole line; a cross rail is to be firmly spiked to a post in the inner and outer row at every one hundred yards along the line on each side, and is to be of the same scantling as the side rails, and to have a centre post as described above. Each field must be fenced off with posts and rails, before any part of the road work is commenced in that field, or before any of the hedges or ditches now existing on the land be removed or cut down. Six field gates, with iron hinges and fastenings, and ground posts, all similar to the best kinds used in the neighbourhood, to be finished and erected; and should more or less be required, they are to be allowed or deducted from the contract at the rate of 3*l*. per gate. At each gate, drains with good tiles not less than ten inches in diameter, or brick drains one foot in diameter, are to be laid in the sides of the Roads; and drains of the same description as the cross ones, one foot six inches in diameter, are to be made in the field or outside ditches, or water channels; the length of these drains to be twelve feet; and a road is to be made over them into the fields, eight feet in breadth, and to be covered with flint eight inches deep, and extending into the fields at least ten feet beyond the line of the quicksets; and no acclivity from the Road into the fields is to exceed one in sixteen, and all the gates are to be hung so as to open towards the fields.

CULVERTS, OR CROSS DRAINS.

There are to be three cross drains of brick masonry, each eighteen inches in diameter, constructed in such parts of the line as may be pointed out by the Engineer. These cross drains are to be conducted under the fences into the ditches on each side of the Road; they are to be 4½ inch brickwork, and built with good mortar; they are to have an acclivity of one inch in ten feet, and to be placed so that the upper surface will admit of six inches of soft mould to be laid between it and the bottom course of gravel, or small flints, without raising the longitudinal surface of the Road. When the cross drains are under embankments, they are to be carried to the extremities of the bottoms of the slopes. Should any drains of a different size be wanted, their situation, number, size, and value to be determined by the Engineer. The water from the surface of the Road is to be introduced into the cross drains by as many side openings or inlets as there are cross drains; these inlets are to be made of brickwork. A shaft is to be carried up from the drains one foot square in the clear, to the level of the road materials. On this well or shaft a metal grate is to be placed, the depth of the bars of which are to be two inches, and their

breadth one inch, and to be placed one inch apart. The water is to be introduced into the cross drains by a row of paving stones across the course, so raised as to prevent it from passing, and the outer row of paving stones below the discharging end to be large stones, sunk so deep as to secure the work from being injured by the current of the water: the lower ends of the drains to be secured by wing walls at least four feet long, and the same at the upper end. These wing walls are to be covered with two rows of green turf, the lower one with the swarded side down, and the other with the swarded side up. Whenever springs are found in the ground over which the roadway is to be made, or in the cuttings, drains are to be made the same as on the outside of the carriage road before described, for carrying the water into the ditches, or natural watercourses, by proper under draining. Open cuts are to be made wherever they are necessary, for carrying the water from the ditches into the natural watercourses; these drains to be two feet wide at top, ten inches wide at bottom, and eighteen inches deep. Where the new line crosses the two roads leading to Flamstead, these roads are to be raised so as to give an easy access across the new line. The acclivity is in no case to exceed one in fifteen. These side roads are to be fenced with one row of post and rails, and a quickset, as before described; and to be coated with flint ten inches deep, and twelve feet wide, for the length of the new work.

METHOD OF COKING COAL.

PLATES CXIX. and CXX.

THE coking of coal for the use of the smelting furnace is sometimes performed in ovens, and at others in the open air. Plate CXIX. contains a plan and section, &c. of the ovens at the Lemington and Northumberland works on the Tyne. A series of ovens are built adjoining each other, each arched over with a barrel arch of fire brick. The bottoms and sides of the ovens are lined with fire brick, and a small flue is formed in the centre of the crown of the arch. A doorway or opening is made in front to admit the coal, and the opening is closed up with square pieces of fire brick, 18 inches in width by 2 feet in length, and $2\frac{1}{2}$ inches in thickness, formed with a rebat round the edges, so as to fit together, and constitute a door, as at A. (Plate CXIX.) These square pieces of fire brick are perforated in several small holes about 2 inches in diameter, so as to admit a small draft of air to support a slow combustion, and they are secured in their places by a bar thrown across, and hooked into a staple.

After the mass of coal has been thrown in through the doorway upon the bottom of the oven in a heap, it is ignited, and the doorway is closed as at A or B, so as to admit the air only through the draft holes. When it has become completely and thoroughly heated into a red heat, which is the case in from thirty-six to forty-eight hours, the doorway is thrown open, and the mass suffered to cool, which takes a considerable length of time; or the red hot coke is scraped out immediately with a long handled iron hoe, and buckets of water are thrown upon it in order to hasten the completion of the process.

The coking ovens which exist in the neighbourhood of Sheffield are mostly hemispherical; about ten feet wide at the base and two feet at the aperture, and the wall eighteen inches in thickness. Parkes thus describes the process of converting coal into coke.

" When these ovens are once heated, the work goes on night and day without interruption, and without any further expense of fuel. It is conducted thus:—small refuse coal is thrown in at the circular opening at the top, sufficient to fill the oven up to the springing of the arch; it is then levelled with an iron rake, and the doorway on the side built up with loose bricks. The heat acquired by the oven in the former operation is always sufficient of itself to light up the new charge, the combustion of which is accelerated by the atmospheric air that rushes in through the joints of the loose bricks in the

doorway. In two or three hours the combustion gets to such a height that they find it necessary to check the influx of the air; the doorway is, therefore, now plastered up with a mixture of wet soil and sand, except the top row of bricks, which is left unplastered all night. Next morning, when the charge has been in twenty-four hours, this is completely closed also; but the chimney remains open till the flame is gone, which is generally quite off in twelve hours more; a few loose stones are then laid over the aperture, and closely covered up with a thick bed of sand or earth. All connexion with the atmosphere is now cut off, and in this situation the whole remains for twelve hours to complete the operation. The doorway is then opened, and the cokes are raked into iron wheelbarrows to be carted away. The whole operation takes up forty-eight hours, and as soon as the cokes are removed, the ovens are again filled with coal for another burning. About two tons of coals are put in for each charge, and the cokes produced are ponderous, extremely hard, of a light grey colour, and dim with metallic lustre.

"When coke is required to be more of the nature of charcoal, the process is conducted in a different manner. The small coal is thrown into a large receptacle, similar to a baker's oven, previously brought to a red heat. Here the door is constantly open, and the heat of the oven is sufficient to dissipate all the bitumen of the coals, the disengagement of which is promoted by frequently stirring with a long iron rake. The coke from these ovens, though made with the same kind of coal, is very different from that produced by the former operation; this being intensely black, very porous, and as light as pumice stone." Both these descriptions of coke enter into the process of smelting; the former is capable, not only of acquiring an intense heat, and lasting a considerable time, but likewise of sustaining a great weight of ore in the furnace without readily falling to ashes; the latter sort are more inflammable, but much less durable.

Another method of coking coal at many of the iron furnaces simply consists in building any number of rough octangular chimneys of fire bricks, on the ground, about three feet in diameter, and between three and four feet in height, leaving square holes on all the sides communicating with a hollow flue in the centre as at A, Plate CXX. The coals are formed into oval heaps or beds, surrounding the chimneys, being piled up in a loose manner, leaving hollow spaces, or interstices, between and throughout the lumps, for the purpose of communicating a draft of air to the chimney. The heap is then covered with ashes and cinder, and several small apertures are made round its base, from whence it is set on fire, and supplied with air. In the course of four or five days, the whole mass is ignited into a red heat, which becomes visible through the covering; when the heap is raked asunder, and the coke thus produced is suffered to cool off.

"By the system of open fires much of the coal must be reduced to ashes before the air is excluded, which is more particularly the case when the wind is high. On a stormy night, the unremitting exertions of a double set of cokers are perhaps required on the coke hearth to keep the fires tolerably covered; and in an extensive work, probably sixty or a hundred tons of coal may be wasted in one night in spite of all their labour.

"The coke hearth of an iron work in full operation presents a grand and imposing spectacle in a dark night. The long rows of flame produced by the burning of many hundred tons of coal, extended over a vast space of ground, and flickering in the wind, the black grotesque figures of the cokers brandishing their long rakes, and partially visible through the thick lurid smoke, with the roaring of the blast, and the noise of the machinery, seem to realise the description of the infernal regions by Virgil or Dante, rather than any thing familiar to our experience in this habitable world."

MANUFACTURE OF IRON.

PLATES CXXI. CXXII. CXXIII.

THE ore from which nearly all the iron manufactured in the United Kingdom is obtained, is that kind commonly called argillaceous or clay ironstone; it is of various colours, grey, brown, and bluish grey, or slate colour, and, to a common observer, would not appear to differ from an ordinary stone, except, perhaps, on account of its greater weight. The iron exists in clay ironstone in combination with oxygen, in that proportion which chemists designate the protoxide; with carbonic acid, and small quantities of earth, carbonaceous matter, and sulphur: the last, however, is not always present. The following is the result of the analysis of nine different specimens of iron ore by Dr. Colquhoun, originally published in Brewster's Edinburgh Philosophical Journal for 1827. The specimens were from Crosbasket, the Clyde Iron Works, from Airdrie, and from Easterhouse, near the line of the Monkland Canal; all from within four to ten miles of Glasgow. From this analysis it appears that one hundred parts of the several specimens were found to contain—

Water - - - - - -	from	0·00	to	0·99.	—Only one specimen contained water.
Carbonic Acid - - -	—	26·35	—	35·17.	
Protoxide of Iron - - -		35 22	—	53·03.	
Protoxide of Manganese - -	—	0 00	—	0·20.	—Only four specimens contained Protoxide of Manganese.
Lime - - - - - -	-	1·90	—	8·62.	
Magnesia - - - -		1 77	—	6·70.	
Silicia (the pure earth of flints)	—	1·40	—	19·90.	
Alumina (the pure earth of clay)	—	0·63	—	8·03.	
Peroxide of Iron - - - -	—	0·00	—	1·16.	
Calcareous or bituminous matter	—	1·50	—	3·03.	
Sulphur - - - - - -	—	0·00	—	0 62.	

Such was the composition and mineralogical details of various specimens of ironstone, which were obtained from component strata of the independent coal formation around Glasgow.

The great seats of the iron manufacture of Great Britain are in Staffordshire, around Wolverhampton, Bilston, and Dudley. In Wales, around Merthyr Tydvil, in Glamorganshire, and in the Forest of Dean, on the borders of Wales. In Shropshire, in and about Colebrook dale. In Scotland, at the Carron Works, near Falkirk, in Stirlingshire, and in the neighbourhood of Glasgow; besides many considerable works in different parts of Yorkshire and Lancashire, &c.

The first process which the ore is submitted to, after being taken from the vein and broken into small pieces, is that of calcining; this is technically called roasting, and consists in the application of a moderate heat, whereby the more volatile components of the ore, as water, carbonic acid, sulphur, arsenic, &c. which enter into its composition, are expelled. In this process a loss of weight is sustained of from twenty to thirty per cent.; and its colour is changed from dark brown, or slate colour, to a reddish oxide of iron. The first of these effects, namely, the loss of weight, is owing to the absence of such matters as may be driven off by the heat; and the second, the change of colour, is supposed to arise from the decomposition of the water contained in the ore, whereby the hydrogen is dissipated while its oxygen is retained. The process of roasting is performed by spreading upon the ground near the furnace a stratum of coals about nine inches thick, ten feet long, and eight broad: these coals are covered with a layer of ironstone about six feet in thickness, interspersed with occasional layers of small cinders and coke dust; the whole is then covered with slack or small coals. Fire is now applied on the windward side, and the heap is suffered to burn as long as combustion can be supported, which will usually go on

for about three weeks. Sometimes the roasting process is performed in a kiln, which is fed at the top as the roasted ore is taken out at the bottom after having been subjected to the requisite degree of heat. Considerable skill is requisite in conducting this preliminary process, for if there be too much heat, or too long applied, the pieces of ore, or, as it is in some places called by the workmen, "the *mine*," will partially melt and adhere together; and if, on the other hand, the heat be insufficient, the water and sulphur, &c. will not be expelled, and the ore must then be thrown aside as unfit for further use in the manufacture of iron.

The next step in the process is to convert the calcined or roasted ore to a metallic state, which is effected in the blast furnace in contact under a very powerful heat, with proper proportions of coke and limestone: the coke serves not only as a fuel for producing the heat, but attracts the oxygen from the ore, and enters into combination with the iron in the state of pure carbon, while the limestone facilitates the melting of the ore by acting upon the silicious and aluminous earths, thus destroying the combination and setting the iron free; as this proceeds, the fluid metal sinks to the bottom of the furnace called the hearth, and the lighter earthy matter rises to the top and floats on the surface of the melted iron, forming what is technically called slag.

The blast furnace in which the metal is extracted from the ore is represented in Plates CXXI. and CXXII. The first is a plan shewing the manner of introducing the blast into the furnace by means of two pipes, the holes through which the blast passes, or as they are technically called *twyers*, being placed opposite and level with each other: it is the general practice to have three pipes, although frequently only two are used, and sometimes only one. The second plate (CXXII.) is a vertical section exhibiting the details of its construction. The ore, the coke, and the limestone, which is used as a flux, is introduced to the furnace through spaces or doorways near the top, as at O. The method of supplying the materials was formerly by workmen, who carried or wheeled them along a slightly inclined roadway or bridge from the ground to the mouth of the furnace; but this method is now generally superseded by the use of machinery. The great body of the furnace is called the cementing part, which is gradually filled with a mixture of ore, coke, and limestone. The blast, which is urged by a powerful steam-engine, enters at E, and produces the greatest heat a little above this point. The ore, which is in a highly heated state, bordering on cementation, in the higher part of the furnace, gradually sinks to the part where the heat is most intense, and where the more complete decomposition takes place. The mass now becomes fluid; and the metal, by its greater specific gravity, drops into the cavity A, called the hearth, while the scoria or slag floats upon its surface and runs off over the dam stone C, beneath an arch formed by the lymp plate and stone D, and is conveyed away by the workmen. When the hearth is nearly full and the metal likely to follow the slag over the dam stone, it is let out at the tap hole, which is on a level with the bottom of the hearth, and which during the process of smelting is closed by a lute composed of a small quantity of sand mixed with clay: the furnace being tapped, by driving a round pointed crowbar through the clay, the fluid metal is conducted into moulds prepared near the orifice producing the heaviest kind of castings, such as the parts of iron bridges, vast beams, wheels, and cylinders of steam-engines, &c. or if not required for the immediate production of such works, it is run into moulds for the bars of pig iron, the form in which cast iron is sold as a raw material: the latter process is represented in the plan, Plate CXXI. The main stream of the fluid metal is called by the workmen the "*sow*," from which numerous side branches are led called "*pigs*;" and as the metal flows along the sow, it is frequently checked by the workmen, to cause it to flow into the side channels while it retains sufficient fluidity to form each pig completely: as soon as the metal is well set, the pigs are broken off from the central channel, and the latter is broken to pieces with a large sledge hammer. The loss of weight sustained in this operation is upon an average about forty per cent. which, added to the loss sustained in the preliminary process of roasting, makes a loss of about sixty or seventy per cent. in obtaining pig iron from the natural ore.

The quality of the pig iron produced in the operation of smelting will vary with the quantity of carbon it contains, which depends in a great measure upon the quantity of coke or charcoal employed in smelting the ore. If the iron has imbibed a great excess of carbon, it will be seen floating on the top surface, as it runs into the pig moulds, in the form of scales: this is called kish, and indicates that the furnace is making the best iron. The appearance and properties of the slag is likewise a good test of

the working order of the furnace. When this assumes a black colour, the product of iron is less than it should be, owing to large quantities of metal entering into combination with the silicious and other impure portions of earthy matter; the most favourable appearance of slag is when it approaches to a bluish tint. Formerly the slag from furnaces was employed in making turnpike roads, &c., but owing to the improved manufacture of iron this article has ceased to be useful for these purposes.

"The pig iron may be divided, first, into foundery iron and forge iron: the former being used in the state of pigs for casting; the latter being only applicable to the manufacture of bar iron. The reason of this is, that, from its nature, it is too thick when melted to adapt itself to the shape of the mould, and when cold is too weak and brittle to be serviceable as cast iron, even if the other objection did not exist.

"There are three qualities of foundery iron; first, second, and third.

"No. 1 foundery Iron differs in its chemical composition from the other sorts, by containing more carbon. It is, indeed, combined with as much carbon as it is capable of holding; and to effect this combination in its full extent, the coke containing the fibrous appearance of charcoal, or the purest carbon, is selected. The tendency of this combination is to render the iron soft, and to make it very fluid when melted; so that it will run into the finest and most delicate mouldings. It is used for small and ornamental castings, and anything that requires a minute and perfect adaptation to the shape of the mould. It is distinguished in its appearance by great smoothness on the face or surface of the pig; and in the fracture it exhibits a large, dark, open grain, intermixed with dead spots of a lighter colour and closer texture. When broken, the pig does not ring, but sounds rather like lead, falling dull and dead upon the block over which it is broken. It is also so soft as to yield readily to the chisel. In running from the furnace, the surface of the melted metal is smooth and dull, breaking occasionally into streaks and cracks of a darker and brighter red. When it is highly carbonised, the pigs and the cinder are frequently covered with a small bright laminæ of a substance (above named) called kish. It is a pure carburet of iron, or black lead, and evinces an excess of carbon in the pig.

"No. 2 foundery Iron is less carbonised than No. 1; not so soft, closer grained, and more regular in the fracture; not so fluid when melted, nor so smooth on the face of the pig: it is, however, harder and stronger, and is preferred for all the less delicate parts of machinery, where strength and durability are required.

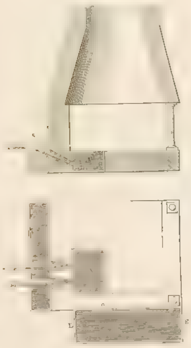
"These two sorts are all that are recognised in some places as foundery iron. Their being combined with so large a dose of carbon and oxygen renders them unfit for manufacture into bars; but iron of the next quality, or No. 3, having less foreign admixture in its composition, is destined indifferently for the forge or the foundery. It is used extensively for castings where great strength is required, or in situations where it is to be exposed to constant wear and tear; such as tram plates, heavy shafts and wheels, cylinders for steam-engines, and many descriptions of heavy work. It is selected for these purposes from being still harder than No. 2, and possessing so great a degree of toughness as well as hardness as to make very strong and durable castings. In appearance it differs from No. 2, in the same way as that does from No. 1, being more closely grained and more regular, and darker when broken. From its appearance it is often called dark grey iron, by which term it is, indeed, as well known as by that of No. 3.

"Mottled iron is used exclusively for the purposes of the forge, as it is too thick and brittle for the foundery. It is smooth in fracture, hardly exhibiting any grain, and appears to be compounded of two qualities imperfectly combined, being spotted or mottled with grey and white.

"White iron is supposed to contain a very small portion of carbon, less than any other sort of pig iron. It is totally unfit for casting, and is sometimes so thick as hardly to run into the pig moulds, although they are purposely made very large; and so brittle, that the larger and most unweildy pigs may be readily broken by a blow with a sledge hammer. It is too hard to yield in any degree to the chisel. The colour of the fracture is a silvery white, shining and smooth in its texture, with a foliated or crystallised structure.

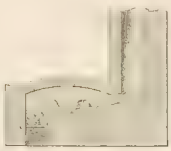
"Thus we have six distinct gradations of pig iron, produced under different circumstances in the blast furnace: No. 1 and No. 2 foundery, No. 3 foundery iron, No. 4 is also occasionally used as a foundery, but No. 5 and No. 6 are exclusively employed for forming malleable iron."

For the conversion of pig iron into malleable iron, the first step in the process is that of refining, which consists in depriving it of its carbon; this is done in a furnace of peculiar construction, represented in plan and section in the annexed engraving.



The recess or trough A is made of cast metal, the bottom consisting of fire stone or brick. It is surrounded on three sides by a space through which water is constantly passing from the cistern C. This contrivance is necessary as a precaution against the intense heat of the fire, which would otherwise soon destroy the castings used for the sides of the refinery. *p p* are two pipes from a blowing machine inserted into the conical openings, and the twyers are kept cool by the water from the pipe s, which runs off at the pipe *t t*. The fire being made in the trough A, and filled with cokes, the metal pigs are laid upon it, and cokes heaped up around them; the blast is next applied, and kept up till the pig iron is brought to a state of fusion, in which state it receives the action of the blast for three or four hours, which liberates a quantity of its carbon. It is then suffered to run out through an opening *o*, temporarily stopped with a lute of sand and clay, into a shallow metal trough D E, by which it is formed into a cake or plate. In the process of refining it would appear that the blast first destroys a portion of carbon on the surface of the melted mass, and then oxidates the iron thus deprived of its carbon. This forms the vitreous oxide of iron, which then floats on the surface of the melted metal, and runs out with it from the furnace to the trough D E. The oxygen of the floating oxide is therefore constantly in contact with the carbon of the metal below. The stratum immediately below gives its carbon to that deprived of its carbon above, and thus the change is effected to the bottom of the trough. The cake of metal, as run out, is very brittle, and is then broken into pieces for the further process of puddling. The appearance and properties of the metal, from the process of refining, is very materially changed: its fracture presents a white silvery brightness, and apparently crystallised, which arises from its loss of carbon.

The process of puddling consists in placing the metal, after it is refined, into a furnace of another construction, represented in the annexed engraving, in which the coke fire is placed towards the extremity of the hearth at A, and is only excited by the draught of the chimney, which is placed at the opposite end, and furnished with a damper, for the purpose of regulating the quantity of heat. The iron is laid upon the metal bottom or floor of vitrified sand, of a concave form B, and the fire is separated from the metal by a low wall C, running across the furnace, but leaving sufficient space for the fire to pass over the iron.



The furnace being heated, the metal begins to melt and flow down to the hearth: when in this semifluid state, the puddler introduces a long iron rod, with which he turns and stirs the mass about, occasionally throwing water upon it with a small iron dish This water is decomposed by the iron and carbon; the hydrogen escaping, and the oxygen uniting with the iron, forming the vitreous oxide; this latter being constantly agitated with the melted metal, continues to dissipate the remaining carbon. During this process, the metal appears to swell and heave, and emits a portion of its remaining carbon combined with oxygen, giving out, from the bursting of bubbles, little jets of white or blue flame. The fusibility of the mass gradually diminishes as the process advances, until it assumes a loose granulated appearance, without the least *apparent* tendency to cohesion; the full force of the draught is then brought to act upon the fire, and the particles begin to cohere; but before the metal becomes a stiff conglomerated mass, the workman forms it into several lumps or balls called blooms, which are then removed from the furnace and subjected to the process of shingling: this consists of several blows from a heavy tilt hammer;

Plate CXXIII. which makes them more solid and reduces them to an oblong shape better calculated for going between the rolls (sometimes the process of shingling is omitted.) The blooms, whilst still hot, are then passed through successive pairs of rollers, similar to those represented at Plate CXXIII. first being put through the largest hole, and then through the smaller ones in succession ; they are received by a boy on the opposite side called the catcher, and handed back by him with a pair of tongs, over the rolls, to the rollers ; thus the metal assumes the shape of bars, about three feet long, six or seven inches broad, and not quite an inch thick.

These bars are next cut into lengths and piled five or six in depth, and are bound together with bands of rod iron. They are now heated in a reverberatory furnace, similar to the puddling furnace, but having a flat hearth. As soon as they are brought to a full welding heat, they are separately brought out and passed again through the successive pairs of rollers. Every time this is repeated the quality of the iron is improved, both in its tenacity and in being freer from specks, which consist of the small bits of vitreous oxide worked up with the iron. If the iron is not intended to be of the best quality, the second rolling finishes the bars for sale.

When the iron is intended to be rolled into sheets, it is first formed into flat bars, and these are cut by large shears into lengths suitable to the breadths of the intended sheets ; these pieces are transversely passed through *plain* rollers, differing from those represented in the plate above referred to in nothing but the gates or grooves for the formation of the bars.

It will be evident, from an inspection of the rollers, that almost every variety of shaped bar can be produced by them, by having the gate or groove in the roller made of the required form. By this process, the large malleable iron rails for railways are produced.

The following statement of the practical result of the process of manufacturing iron from the ore, is taken from the Encyclopedia Metropolitana.

" The quantity of malleable iron produced, compared with the quantity of raw *mine* employed, amounts to about 23 or 24 per cent. at a medium. We may now state the quantity of coal employed. First, the coal is to be converted into coke, and in this process there is a waste of weight of about 33 per cent., or a product of 66 per cent. ; and the quantity of coke and of roasted *mine* employed in the furnace are nearly equal ; but more accurately the proportions may be stated as 100 coke, or 100 coal, to 80 raw mine, or to $26\frac{2}{3}$ pig iron ; that is, $3\frac{3}{4}$ tons of coals are consumed in the furnace, and 3 tons of raw mine, to produce one ton of iron. It is also estimated that one ton of coal for every ton of iron is consumed in the kiln and in the steam engines for the blast, and about one ton of limestone as a flux to each ton of iron. The actual weight of material consumed, therefore, in the production of a ton of pig iron, may at a medium be stated as follows :—

Raw mine	3 tons	= 2·4 tons of roasted ore
Coal for furnace	$3\frac{3}{4}$ tons	= 2·5 of coke
Ditto for kiln, &c. engines . . .	1 ton	
Flux	1 ton	
	$8\frac{3}{4}$ tons of material for one ton of pig iron.	

" This is the amount of materials requisite to produce a ton of pig iron ; but a reduction of weight takes place in converting the pig iron to the finished bar, in the ratio of 33 to 24. To produce, therefore, a ton of finished bars, these materials must be increased in the inverse proportion, or as 24 to 33, or in the ratio of 8 to 11. Hence, to produce a ton of finished bar, there will be required,

Coals for kiln, steam engine, and blast furnace . .	6·53 tons	
Raw mine	4·12	
Limestone	1·37	
		12·02
Add to this, Coals used for refinery .	0·61	
Do. in puddling, &c. . . .	1·90	
		2·51
		14·53 tons,

used in the production of one ton of finished bar."

MANUFACTURE OF STEEL.

Plates CXXIV. to CXXVII.

Steel, which is a carburet of iron, depends for its quality upon the method of impregnating the pure iron with carbon, which may be done to a certain degree without destroying its malleability. Foreign iron is mostly employed for conversion into steel, and by far the most celebrated for this purpose is that from the Dennemora mines in Sweden, which owes its superiority to some properties with which we are almost entirely unacquainted. It is distinguished in commerce by the name of "hoop L," and bears a mark of the letter L, surrounded by a circle or hoop. The foreign iron, when imported, is mostly in flat bars, varying in length from seven to fourteen feet, and, in like manner, differing in strength also; it is in this state they are passed through the fiery ordeal which converts them into steel.

The recarbonization of pure iron, which converts it into steel, is performed by the agency of powdered charcoal, which is made to surround it in successive layers, within cases or pots, formed with fire bricks or fire stone. These cases must be made sufficiently strong to withstand a great heat; they should not be liable to crack or fuse by the action of the fire to which they must be subjected. Their dimensions are about eight or ten feet in length, twenty-two inches wide, and thirty-three inches in depth. A layer of powdered charcoal of the best quality is first put into each pot, covering the bottom to the depth of two or three inches; upon this a layer of the bars of iron, side by side, separated a little from each other; then other layers of charcoal and of bars alternately until the case or pot is filled, taking care that each bar is completely surrounded, and covered with the powdered charcoal, and making the top layer of this substance considerably thicker than those beneath. The whole is then covered over with a luting composed of a mixture of sand and clay that will not easily vitrify; this is done to prevent the charcoal from taking fire by the surrounding flame, and confines the action of its carbonaceous quality as much as possible to the iron.

The furnace or oven contains two cases or pots. The fire is made with bituminous coal upon a grate below, and between the cases or pots; and the flame consequently passes under and between them in every direction, and reaching the arch of the furnace is reflected back upon them again. The heat is thus maintained at an elevation nearly sufficient to melt the bars in the cases, and at the same degree in all parts of the cases. This is important to the successful result.

In order to ascertain when the heat and impregnation is complete, one of the bars put in the cases along with the rest is made long enough to reach through to the outside of the furnace, which is called the test bar, and is occasionally pulled out, and examined by the appearance of the blisters caused by the carbonic oxide upon the surface of the steel to ascertain whether the metal is sufficiently converted or not. In deciding on these appearances, much judgment and experience is required; for

the formation and size of the blisters depend almost solely upon the quantity of heat, and are not to be taken alone as a proof of the quality and perfection of the metal. Mr. Buttery, of the Monkland Steel Works, in a communication to Dr. Ure, says, " When the iron has absorbed a quantity of carbon in the blister steel furnace sufficient to constitute steel of a proper degree of hardness, and the heat after this is continued to be kept up, the steel will keep absorbing more and more carbon. The fusibility will continue to increase just in the same proportion, till at last it becomes so fusible, that even the limited heat of a blister steel furnace brings it down; and just at the time it is passing to a fluid state it takes so great a quantity of carbon, as changes its form from the state of steel to that of cast iron. It appears to me that the charcoal is combined in rich cast iron in the mechanical state, and not in the chemical, as in steel." After the heat has been kept up for the space of six or seven days and nights, it is generally found that the conversion has advanced sufficiently, and the heat is made to subside gradually during the same length of time, when a man enters the pots to remove the contents: the bars, which were before as smooth as the forge hammer left them, are now covered with large or small blisters; and on breaking the bar, the fracture, which, in the iron state was comparatively fine grained, is now crystallised, or rather lamellated; its brilliancy is of a grey colour, and less glittering than before. In this state the metal is called *blistered* steel. Blistered steel thus made is used only for the coarsest purposes. Its texture is greatly improved by being formed into smaller bars under the tilt hammer (having been first moderately heated): it is then known by the name of tilted steel.

In the foregoing process, which is called *cementation*, various degrees of hardness may be produced by adding more or less carbon with different degrees and duration of heat. Springs of all kinds contain the smallest proportion; while cutlery, and still more, files, require the introduction of larger quantities of carbon. The best steel, as before observed, is made from Swedish and sometimes Russian iron, which have the property of peculiar tenacity. English iron is not considered to make good steel; nor is it at all brought into competition with the Swedish. The coke of bituminous coal is not employed in the manufacture of *blistered* steel.

Plates CXXIV. and CXXV. represent a plan and section of a blister steel furnace. A A represents the two cases or pots (the same letters of reference are applicable to both plan and section) into which the bar iron and powdered charcoal are placed in successive layers. Their bottoms are formed with two courses of fire brick, laid upon and supported by a number of detached courses, built in the shape of small piers of brickwork, four or five courses in height, with spaces or flues between them, underneath the cases, to conduct the flame. The sides and ends are made of fire brick, five or six inches in thickness, and are supported by detached piers, built between them and the side walls of the furnace, in the same manner as the bottoms, leaving spaces or flues in a vertical direction between the piers, so that as little heat may be kept from the cases or pots as possible. The inner sides, or those facing each other, are supported from one another by small piers, represented by the dotted lines across the fire grate, built also in the same manner, with spaces or flues for the passage of the flame, see *a*, *a*, *a*, *a*, &c. The sides of the cases may be built with brick, five inches in width, in consequence of there being less heat and pressure upon them than upon their bottoms.

B is a test bar, laid in the middle of a tap hole in the end of the case or pot, along with the iron to be converted; the bar is made long enough to reach through the external wall, as at *p*, and is drawn out occasionally to examine the process as it advances. These test bars are placed in the centre of the case, in order that a true estimate may be had of the state of the other contents.

C is the firegrate, made of bars laid lengthwise through the furnace, having two fire doors, *c c*. The ash pit, which is immediately below, must have a free communication with the open air, so as to convey a fresh current always under the grate; it should be six feet in depth, having steps at each end entrance to descend into it, so that a fireman may observe and keep up a regular heat upon the grate from end to end. The fire grate is made open at both ends, but the air is excluded from these openings by piles of coals which are kept constantly in them. From these piles the coal is thrust in upon the grate with a hoe as occasion may require, and the piles are immediately replenished to prevent any air from passing in above the grate.

D D are the doorways at each end of the grate passing through the outer walls of the furnace. When the fire is lighted, the doors are walled up with fire bricks, laid in, and closely jointed with fire-clay, which are taken down when the process is finished and the furnace cooled off; a man then enters through the aperture to uncover the cases or pots and take out the bars of steel.

The furnace is arched over with a barrel arch made of nine inch fire-brick, having ten flues, *e, e, e*, &c. each nine inches square, formed through the spandrils and ends of the vault V, V, communicating with the base of the large conical chimney above. The conical chimney surrounds the flues, and is twenty feet in diameter at the base. It is thirty-four feet in height, from the top of the arch of the furnace: it is made this height in order to create a greater draft of air, and to prevent the external air from descending through the top of the cone into the small flues of the furnace, where they pass through the vault.

F F are spaces of eighteen inches in width, left between the inner walls of the furnace and the outer walls of the building, which are filled with sand and stone rubbish, in order to keep in the heat and to protect the walls.

SHEAR STEEL.

Shear Steel, which takes its name from its being very suitable for making shears, is also used in the manufacture of the better sorts of cutting instruments generally. For the conversion of blistered into shear steel, five or six pieces of the former, about thirty inches in length, are placed upon each other, and the ends of the whole inserted into a stout square hoop at the extremity of a pole of iron, five or six feet long: thus prepared, it is placed in a wind furnace, until the whole mass becomes of a welding heat, sand being meanwhile frequently scattered over it, which forming a kind of glaze, has a tendency to prevent the metal from fusing or burning away. When reduced to a glowing heat, the mass is withdrawn from the fire and placed under a heavy forge hammer, striking slowly at first, and then quicker, until the whole is drawn into a rod about two inches square; it is then cut in the middle, placed together, and welded again as before; being afterwards reduced to the size required. Sometimes this process is again repeated; and is called "*double* shear," "*single* shear," or "*half* shear," according to the number of repetitions the doubling and welding may have been submitted to.

CAST STEEL.

Cast Steel is made by fusing blistered steel. The crucibles in which this effected are made of the best Stourbridge fire clay, mixed with a small quantity of powdered charcoal, to prevent their cracking in heating and cooling. They are about eight or nine inches in diameter, and two feet in height, and are calculated to contain about thirty or thirty-five pounds weight of steel, broken into pieces of three and four inches in length. The cover or lid is made more fusible than the body of the vessel; so that when exposed to the heat, a slight vitrification unites the top and the crucible, and excludes the air before the steel has arrived to such a temperature as to be destroyed by the oxygen.

The crucibles containing the broken pieces of steel, having been covered, are placed upon a stand made of the same materials, and fixed on the middle of the fire grate A (Plates CXXVI. and CXXVII. the letters of reference are the same for both Plates,) in the plan and section, and surrounded by coke of the hardest kind, which is found to produce a greater heat, and for a longer time, than soft coke. The fire is then made, and the steel fused at a white heat; when the crucible is taken out at the top opening B, by the tongs C, and the liquid metal poured into the mould D, where it receives the form of an ingot, two inches by three inches in width and depth, and about three feet long. After the metal has become cool, the bars are taken out of the moulds, and heated again; when they are drawn into long bars, under the operation of a tilt hammer. They may be reduced to the size of half an inch square, or into rods much smaller, if desired, by means of rollers indented or grooved so as to give them the requisite shape.

Steel can be fused with a very small quantity of carbon, so that pieces of it can be afterwards welded together, or with iron, as the case may be. Cast steel is made, by this process, entirely free from the defects incident to blister and shear steel. It is hardened in various ways; generally by heating it red hot, and dipping it into cold spring water. Files are hardened to a still greater degree, by adding salt to the water, and mixing it with sulphuric acid. Oil, mixed with tallow and bees wax, and a small portion of resin dissolved in the mixture when hot, is used for hardening thin plates of cast steel, such as saws and springs: this preparation will not conduct the heat away so rapidly as the others, and it prevents the metal from cracking, by producing a gradual change in its temperature.

The process of tempering steel into a soft and elastic state, from the hard state, requires great attention to the degrees of heat, and a kind of skill, which is, perhaps, obtained only by long practice. It occurs not unfrequently, that the metal, when red hot, returns to its original state, unless managed with great address and care.

The following table by Mr. Mushet shows the proportions of carbon which combine with iron during the formation of the different carburets :—

Soft cast steel	$\frac{1}{120}$
Common cast steel	$\frac{1}{100}$
The same steel but harder	$\frac{1}{90}$
The same too hard for drawing	$\frac{1}{50}$
White cast iron	$\frac{1}{25}$
Mottled cast iron	$\frac{1}{20}$
Black cast iron	$\frac{1}{15}$

The following are the specific gravities of steel in different states :—

Best blistered steel	before hammering	7·31
Ditto	after hammering	7·73
Very hard steel		7·26
Melted steel wire		7·50
English cast steel hammered		7·82 to 7·91

MINES AT ABERSYCHAN, MONMOUTHSHIRE.

Plate CXXVIII.

The British Mining Company purchased about two thousand acres of land, abounding with coal, iron, and limestone, situated in the Valley of Abersychan, about three miles from Pontypool, in Monmouthshire. In the midst of these rich and almost inexhaustible mines, the Company have built six or eight furnaces, upon a large scale, at the same time that they are entering levels into the coal and iron veins, which lie in contiguous strata, above and below each other. It is their chief aim, in opening these mines, to enter the veins at the side or declivity of the hills, upon different levels, taking care to place the furnaces as low in the valley as possible, in order that the coal, ore, and limestone, may be brought with facility upon a level with the opening at the top of the furnace made for the introduction of these materials.

The mines are entered by forming an opening six feet in width, and seven feet in height, which is arched over as the miners proceed forward, until the formation of the superstratum becomes solid and

firm enough to form a roof of itself. They shore up the weak and loose parts, where they occur, and push on with the vein in various directions; taking care, at every course or parting, to sink a shaft from the upper surface, for ventilation. The bottom, or floor of the opening, is formed nearly on a level, or very slightly ascending; just sufficient for the purpose of drainage, which is effected by gutters on each side. In the middle of the floor, a tram-road is made of flat cast-iron rails, with a flange on the inner side, which are laid about three feet apart, leaving a space of eighteen inches on each side for the gutters or drains. Upon the tram-road, there are various passing places formed for the rolley waggons, which may be pushed in, and dragged out, either by man or horse power. (See Plate CXXVIII.)

GAS WORKS.

PLATES CXXIX. and CXXX.

The first of these Plates is the same as given by Mr. Strickland, the American Engineer, in his Reports to the Pennsylvania Society for the Promotion of Internal Improvement. The second Plate contains reduced copies of working drawings obligingly furnished for the purpose by Mr. Richardson of Dudley, whose extensive experience in the manufacture of the apparatus of Gas Works is well known. The details of these Plates are sufficiently obvious to need much explanation.

Both oil and coal have their advantages, as the material from which the gas is to be prepared. In the developement of coal gas, coke and tar are produced in great quantities, the sale of which reduces considerably the final cost of the process. The manufacture of it, moreover, is said not to require the same degree of care and attention as that of the oil gas; for if the oil retorts are heated beyond a certain point, a considerable waste is occasioned. On the other hand, the sulphuretted hydrogen, which is given out by the coal, is objectionable on account of its strong odour, and its tarnishing effect on metallic surfaces; and the oil gas, from the experiments which have been made, appears to give the more intense light. Perhaps, oil gas is to be preferred for drawing-rooms and shops; but in England, until the cost of oil is greatly reduced, the coal gas will continue to be almost exclusively used for lighting the streets of cities, and the areas of large public buildings. At present, the cost of the oil gas seems to be about the double of the other. A chaldron of Newcastle coal will evolve about nine thousand cubic feet of gas, and will produce at the same time about a chaldron of coke, and a hundred weight and a quarter of coal tar. A gallon of whale oil will make about ninety cubic feet of gas.

The retorts which are used for coal are made of various sizes, and differing much in form. Those at the Liverpool Gas Company's works are (as stated by Strickland) shaped like the boiler of a low pressure steam engine, with sheet iron plates riveted together, and with a cast iron head, projecting about eight inches from the face of the furnace. Their dimensions are five feet wide by six feet six inches long, eighteen inches deep at the centre, and one foot deep at the sides. Each of these retorts will work up a ton of coal in twenty-four hours, making on an average seven thousand cubic feet of gas. The Liverpool Gas Company formerly used cast iron retorts; but have, since the year 1821, employed retorts of wrought iron exclusively, in consequence of the more perfect and rapid carbonization which they produce. The following Table exhibits the amount received by them in six successive years, during part of which the cast iron and wrought iron retorts were severally used.

Years	Coal.	Retorts.		Coke.	Rent of Gas.
1818	862	Cast Iron - -	754	443	£5,207
1819	1484	Do. -	951	615	7,050
1820	2524	Part cast iron - -	868	1014	9,858
1821	2262	Do. - -	1078	1024	10,855
1822	2196	Wrought iron - -	460	1005	13,139
1823	2725	Do -	526	1090	16,318

At these works, thirty-four retorts are used at a time, in the winter season, and twelve in the summer. These are generally sufficient for the supply required, but a number of additional retorts is always kept in readiness to meet an increased occasional demand. The works were attended, when Strickland wrote in 1825, by sixteen men, who were divided into gangs of eight, each of which is engaged twelve hours out of the twenty-four. Their duties include all the departments of the establishment, the repair of apparatus, fitting up burners and lamps, cutting screws or pipes, &c. as well as the preparation of the gas.

The furnaces in which the retorts are heated are represented in the accompanying drawings. (See Plate CXXIX.) The gas rises in an impure state from the retorts, through vertical pipes in front of the furnace, into a larger horizontal or nearly horizontal conduit, which is connected with a condensing apparatus. The tar and ammoniacal liquor which are suspended in the coal gas, are here deposited, and drawn off by pipes into a tar vessel. The gas passes through the condenser into a purifying box, and thence is received into the gasometers or gas reservoirs for use. The condensing apparatus is merely a large water-tight box, constantly filled with water, through which a chamber or tube (generally of a rectangular section, with a small base and high sides,) is made to pass with many flexions, so as to expose the impure gas which it receives to as much cold surface as possible: stop-cocks are arranged on the lower side of the chamber, to draw off the tar and liquor. The purifier is an air-tight vessel, generally of a cylindrical shape, containing lime-water. A small interior cylinder, secured at the top to the head of the greater cylinder, but open below, descends to within a short distance of the bottom. A vertical shaft passes through a stuffing box in the head of the cylinders, and rests on the centre of the bottom; and vanes or agitators are affixed to it near its lower end, which revolve by the motion of the shaft on its axis, and thus keep the particles of lime from settling. The gas is admitted at the head of the inner cylinder, passes under its lower edge through the lime-water, which detains the sulphur and carbonic acid, and is finally discharged by pipes which are fitted for that purpose in the upper part of the outer cylinder. This process is admitted to be insufficient to free the gas entirely from its noxious smell, and from the other qualities incident to a certain mixture with sulphuretted hydrogen. Various expedients have been devised, in the hope of obviating these strong objections to the use of the gas. It has been proposed to submit it to the action of lime, in a dry and in a semi-fluid state, and to pass it through iron tubes at a low red heat.

The tanks, in which the gasometers are made to float, may be built of brick-work, curbed on the top with stone or iron, and either of a square or round shape; the latter, however, is more generally approved. The dimensions of those at the Liverpool works are forty-five to fifty feet in diameter, and twenty four feet in depth. The gasometers are made to nearly fill up the tanks, leaving only sufficient space around for them to move up and down freely, without coming into immediate contact at the sides. They are of sheet iron, riveted together, and tarred over or painted on the outside, so as to be perfectly tight.

The gas is conducted through the streets by cast iron pipes, called mains, which are of diameters from eighteen inches to one inch and a half. From these, branches extend into the houses, made of copper or hammered iron, turned on a mandril, and welded in the manner of gun-barrels, in lengths of two, four, six, and nine feet. The mains are united by joints of a conical form, one end of each pipe having a slightly conical termination turned on it, and the other end having a corresponding cavity or socket. The turned end is covered with white lead, mixed with linseed oil, and then driven tight by a wooden mallet. The small pipes or branches have a screw cut on each end, alternately male and female, and by these they are tightly and securely attached to each other. A variety of modifications have been made of these pipes, for dividing the gas received by them among several minor branches, and for turning corners, &c. At present (1825) the prices in Liverpool, of the kinds of iron pipes most commonly used, are as follows:

For mains, including boring and turning the ends,	3	inches in diam.	5*s*. 8*d*.	per yard in length.
	2	do.	4*s*. 6*d*.	do.
	1½	do.	3*s*. 6*d*.	do.
For hammered and welded iron branches,	1	inch in diam.	8½*d*.	per foot.
	¾	do.	6½*d*	do.
	½	do.	6*d*	do.

There is always much difficulty in preventing leaks from the gas pipes of conduit. Mains should be proved by very powerful pressure, before being placed in the line; and if, under a force equivalent to the pressure of a column of water three hundred feet in height, they exhibit any evidence of looseness of texture, they should be absolutely rejected. Too much care cannot be taken to secure the joints. To this end, in setting the mains and branches, a variety of precautions are used. But, notwithstanding every proof has been resorted to, after a time leaks are discovered in every long line of pipes. Pipes which had undergone the test of a pressure equal to one hundred and fifty or two hundred pounds on the inch, have afterwards allowed the gas to escape.

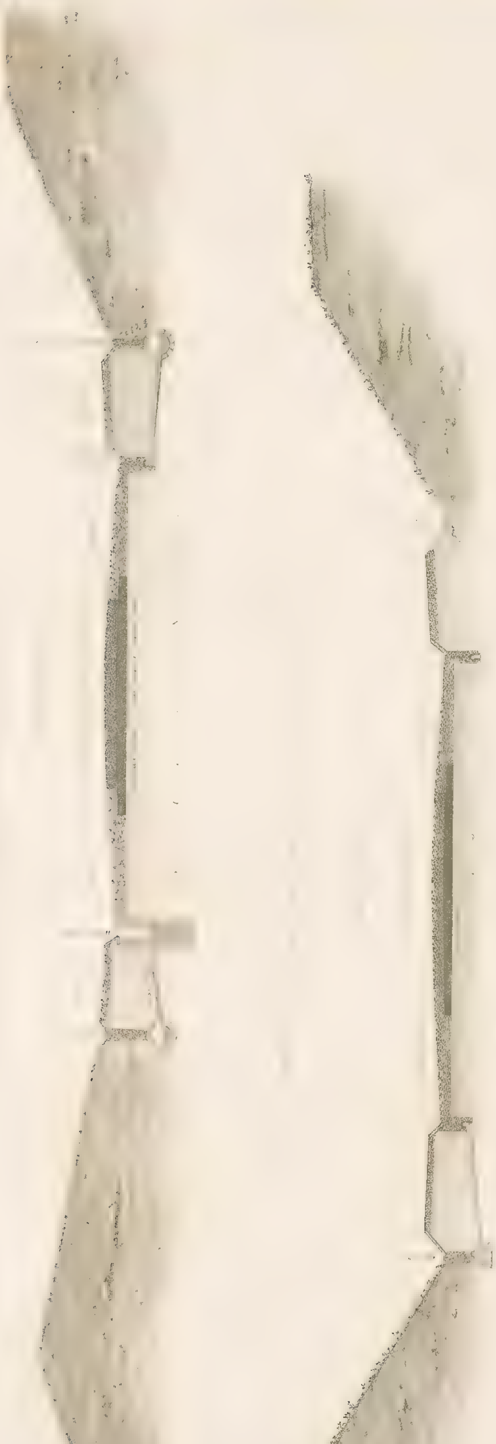
The lowest ground ought to be selected for the erection of gas works; and the mains should, as far as possible, be laid on a line descending to the works. Care should be taken, that they do not unnecessarily dip or bend downwards, which is apt to cause the gas to burn unsteadily. It is, however, important, as water and tar are always deposited in the pipes by the condensation which they produce, that there should be, in the line of mains, a certain regular slope to occasional small reservoirs, where the impurities may be collected and drawn off. For this purpose, a slope of one foot in four hundred and fifty is deemed sufficient on the mains; and, with the view of freeing the branches from the same impurities, they are placed with a dip of one inch towards the mains, in every ten or twelve feet.

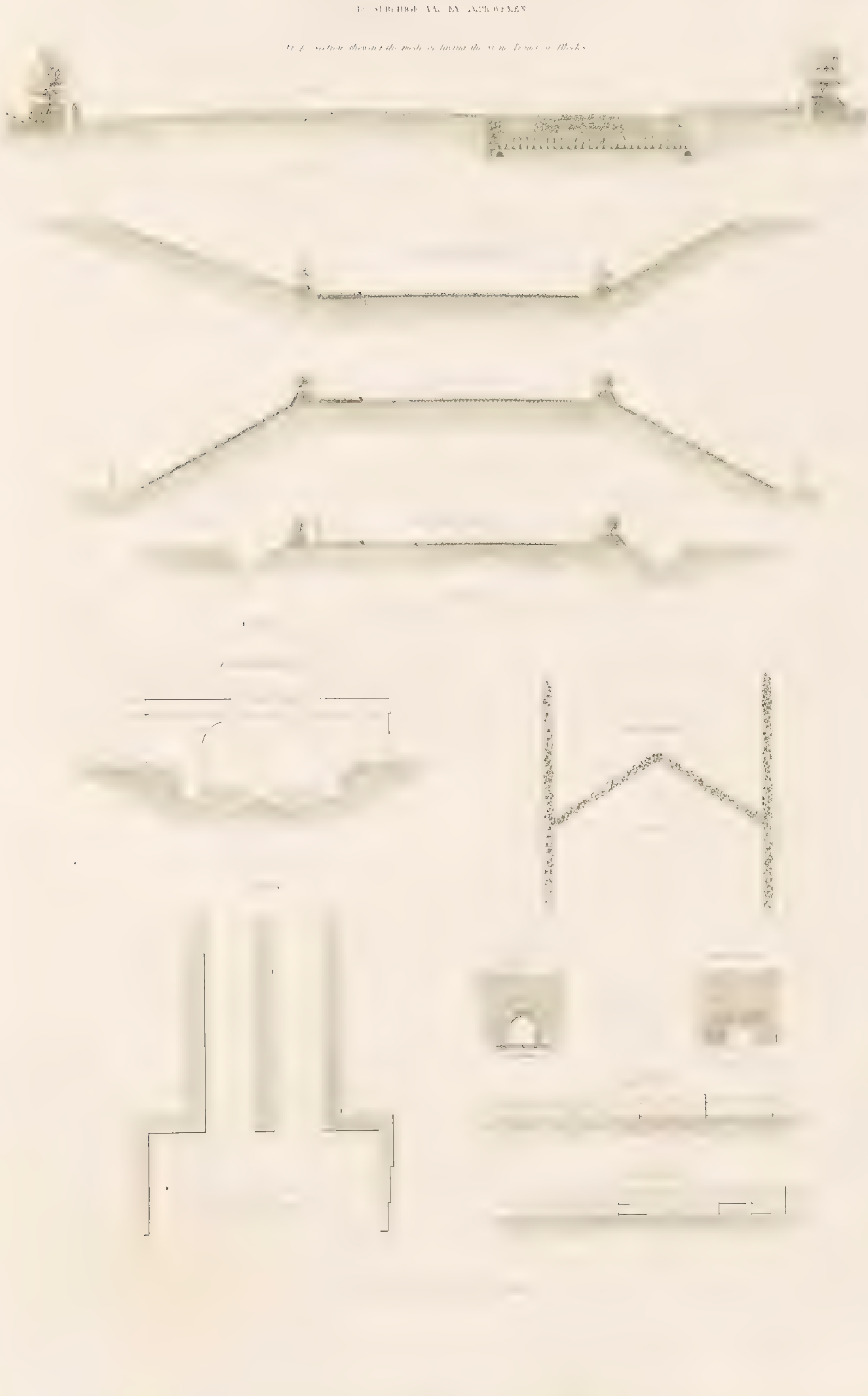
The following Table of Cast Iron Socket Pipes for Gas Mains has been furnished us by Mr. Richardson above-named:

Interior diameter.	Length	Weight of each Pipe.		
Inches.		cwt.	qrs.	lbs
1½	6	0	1	4
2	6	0	2	0
2½	6	0	2	10
3	9	1	0	14
4	9	2	0	0
5	9	2	2	0
6	9	3	0	0
7	9	3	2	0
8	9	4	0	0
9	9	5	0	0
10	9	6	2	0
12	9	8	1	0
14	9	9	2	0

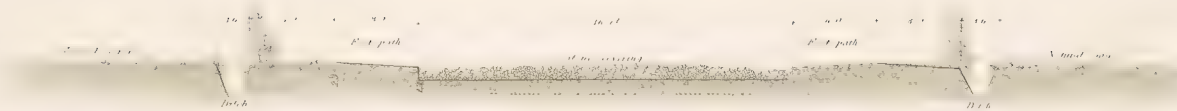
END OF DIVISION III.

LONDON: J. B. NICHOLS AND SON, 25, PARLIAMENT STREET.

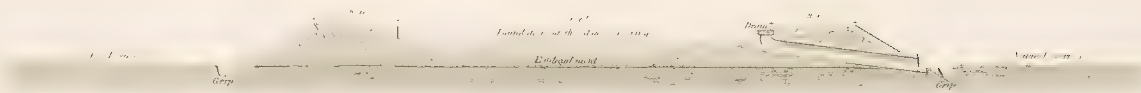




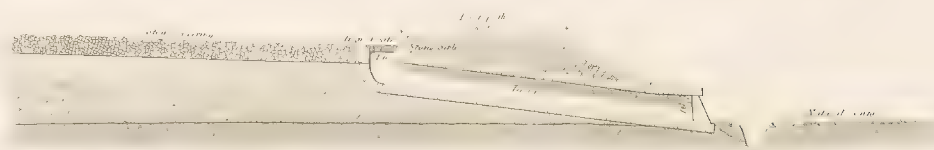
TURNPIKE ROADS.



Transverse Section of a Road formed on the natural surface



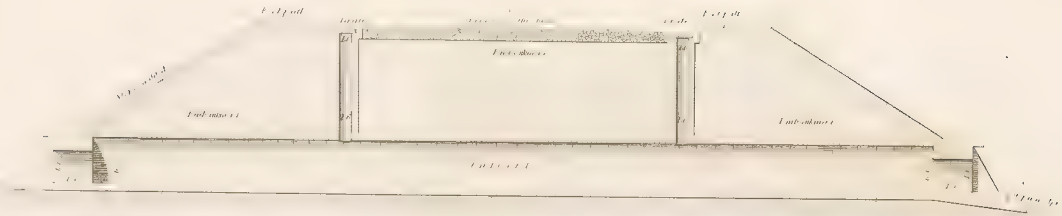
Transverse Section of a Road embanked two feet, shewing the cross drains under the foot path.



Half section shewing the Drain

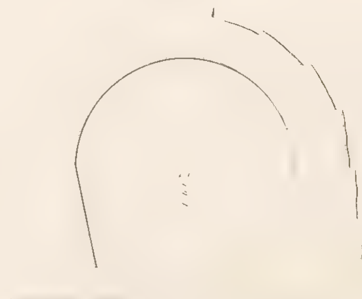
SECTION OF AN EMBANKMENT,

Shewing the discharge of the Road drains into a Culvert.

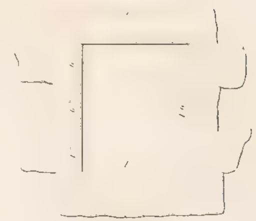


SECTION OF A CULVERT

TRIANGULAR DRAIN

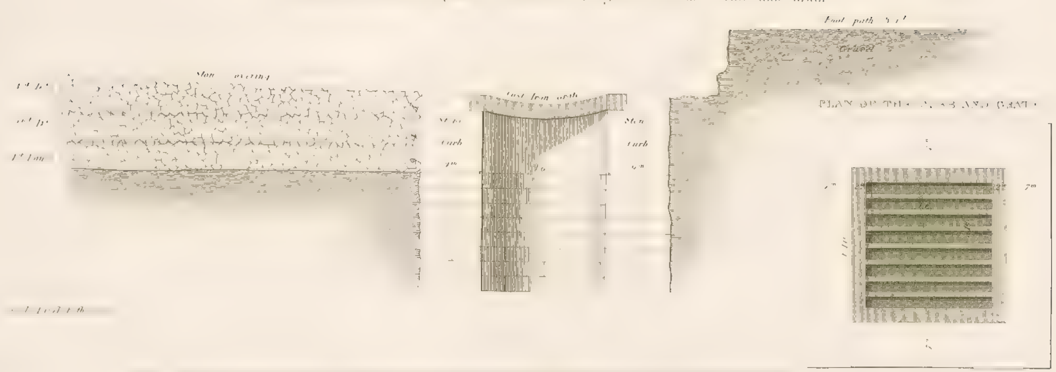


SQUARE DRAIN



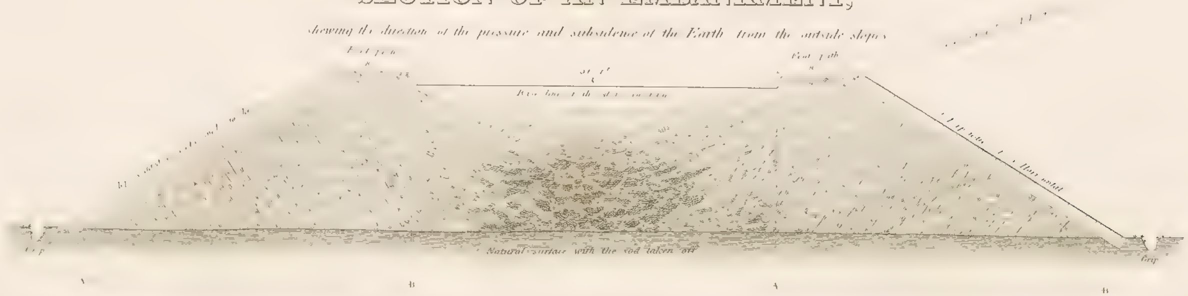
SECTION IN DETAIL,

shewing the successive layers of broken stone, together with the grate and drain

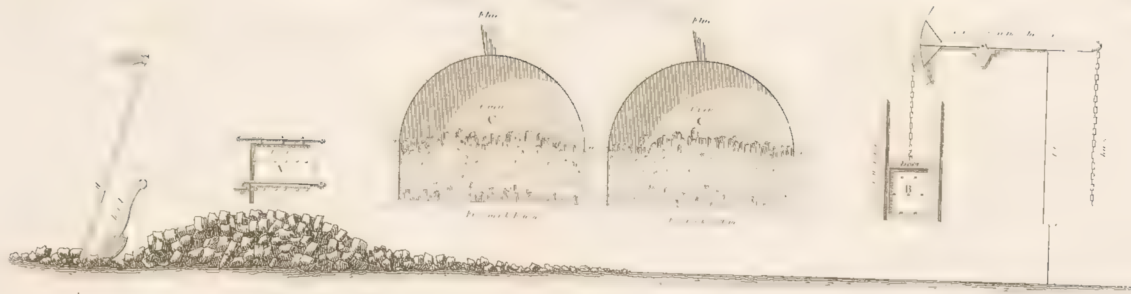


SECTION OF AN EMBANKMENT,

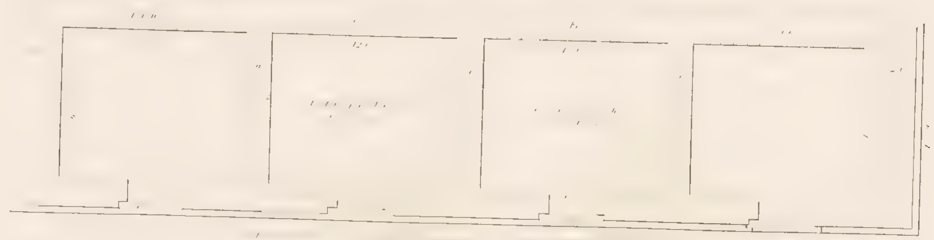
shewing the direction of the pressure and subsidence of the Earth from the outside slopes

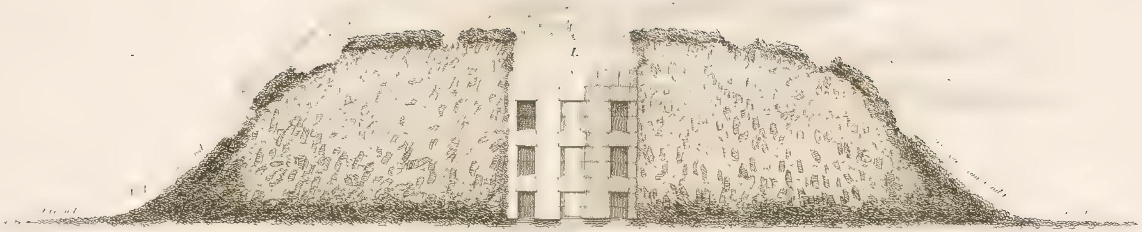


Wm. Strickland Archt & Engr.



ELEVATION & SECTION OF OVENS FOR MAKING COKE

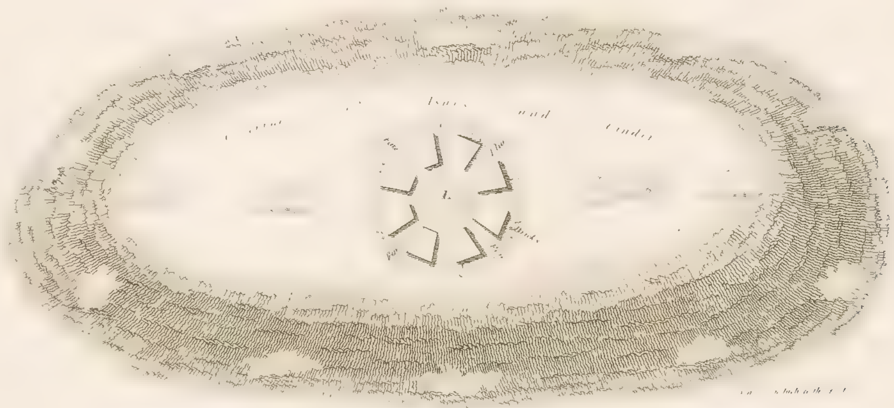




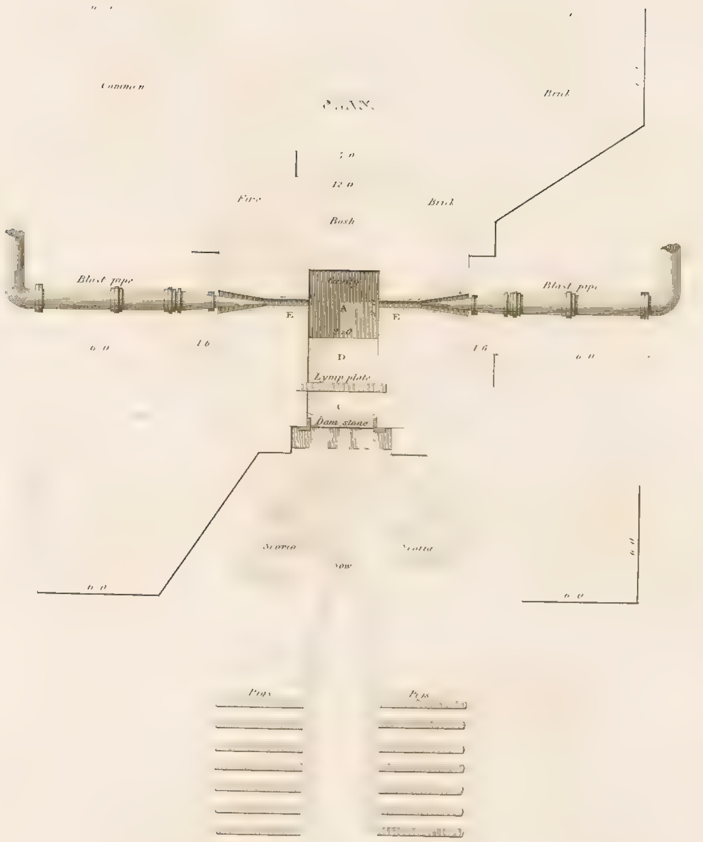
Elevation

METHOD OF COKEING COAL

at the Clyde Iron works

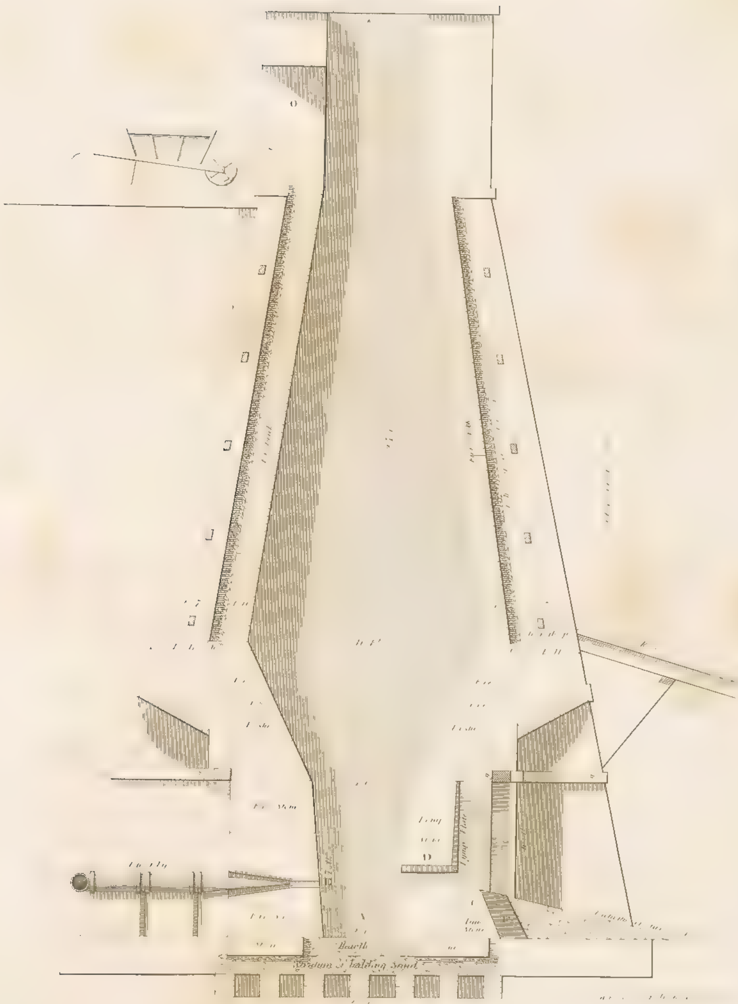


PLAN



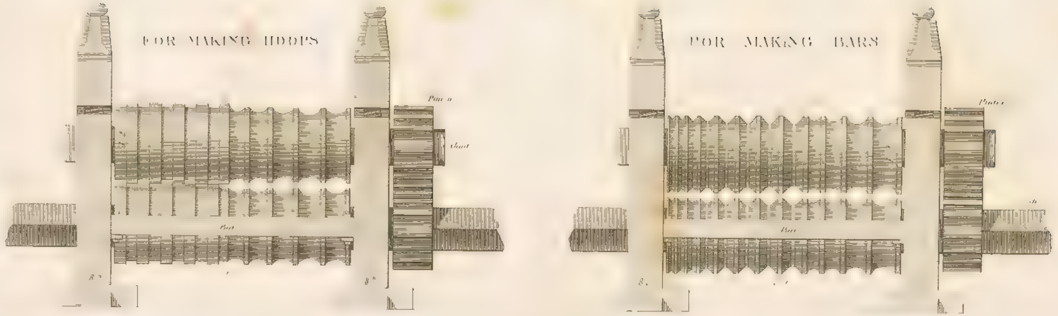
BLAST FURNACE.

SECTION

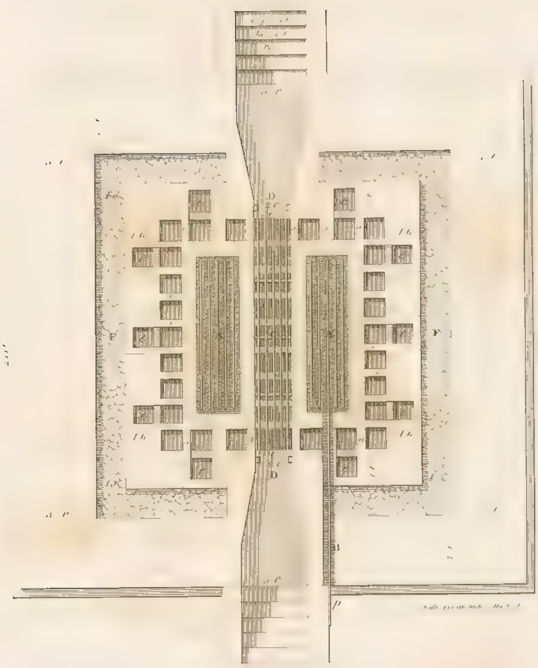


BLAST FURNACE.

CAST IRON ROLLERS.

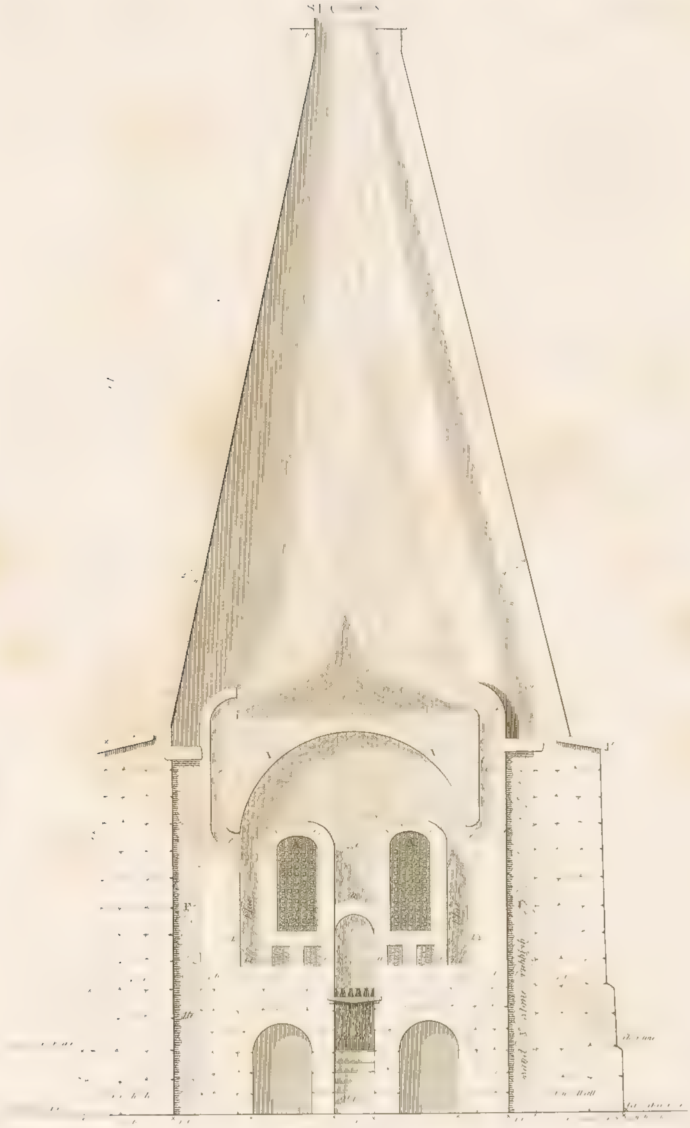


PLAN.

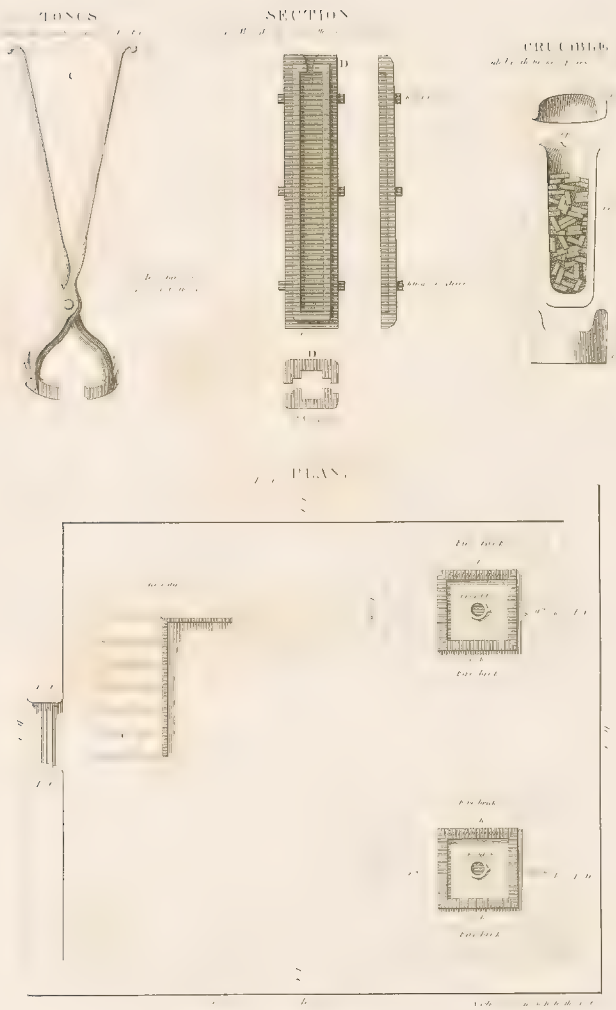


FURNACE,

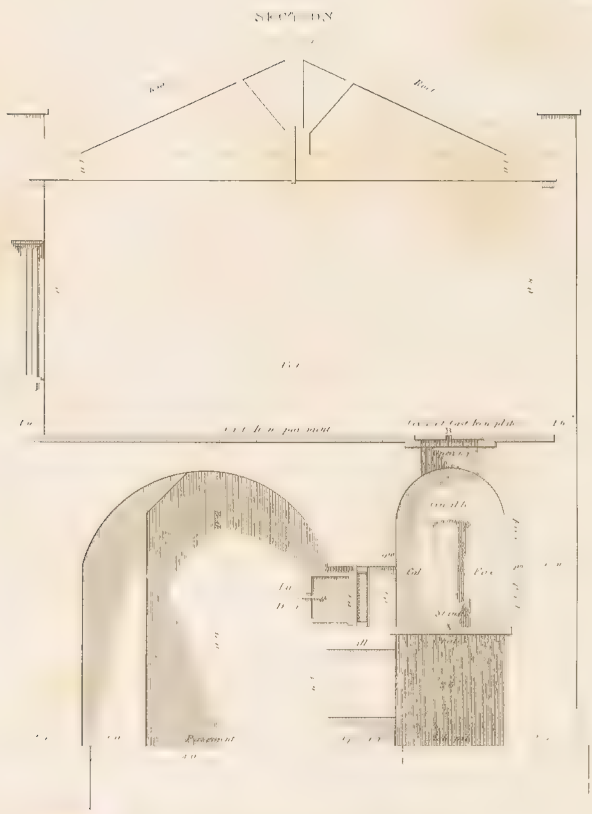
for Converting Bar Iron into Steel.



FURNACE,



HOUSE AND FURNACE.

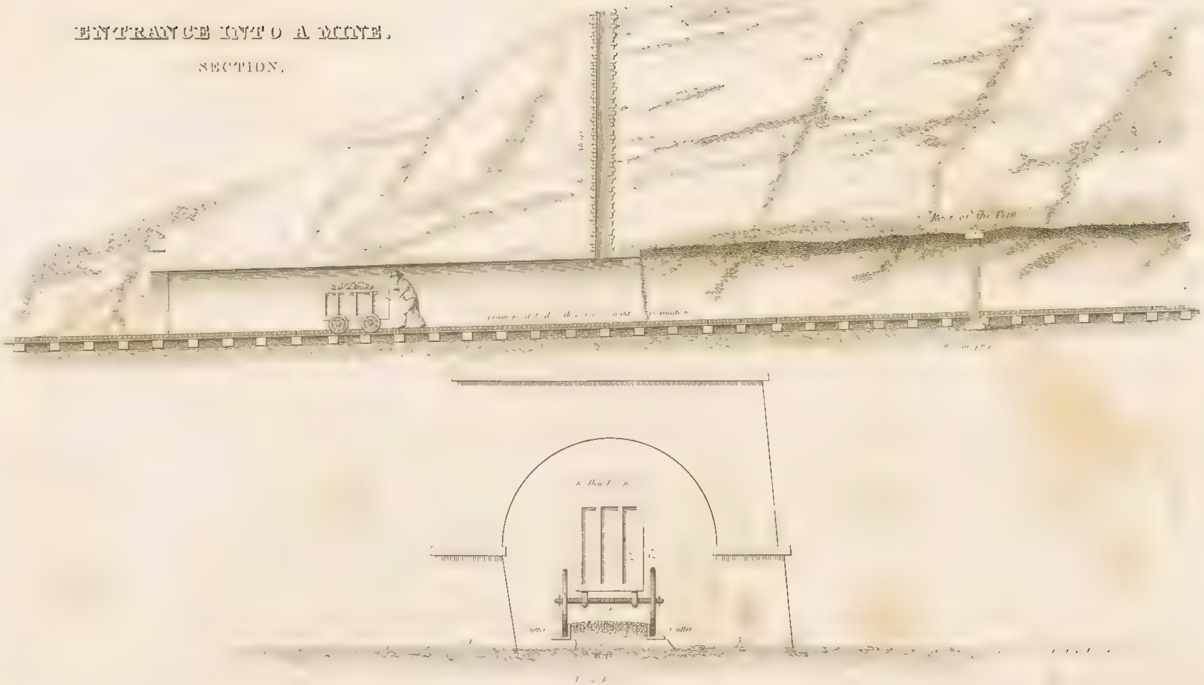


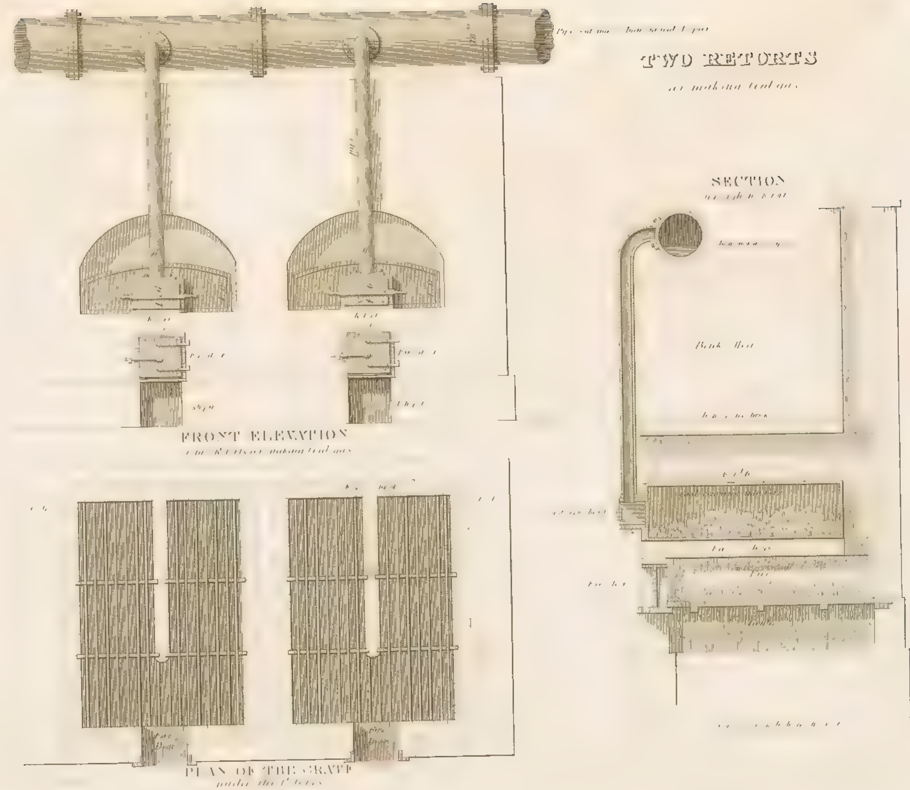
HOUSE AND FURNACE

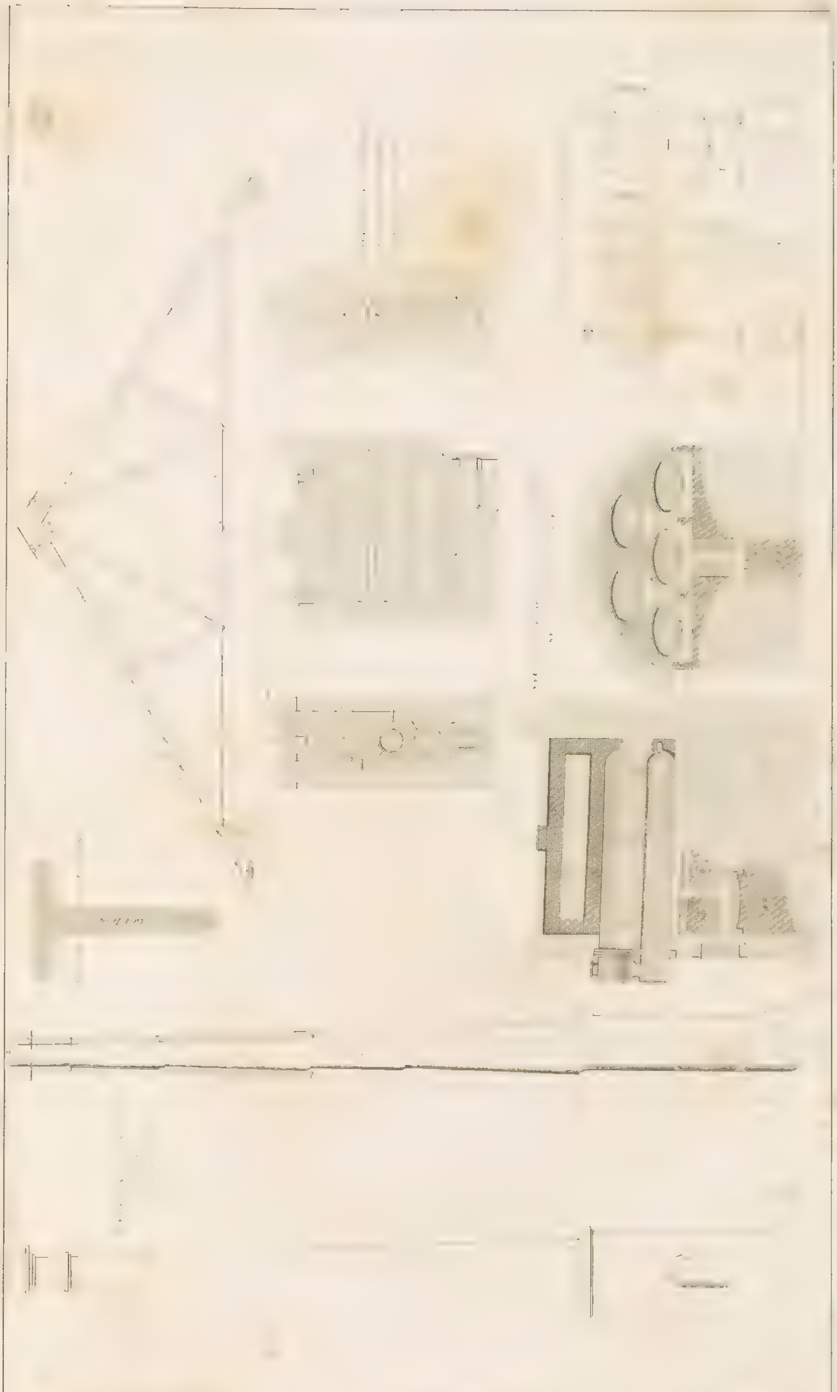
for Casting Steel

ENTRANCE INTO A MINE.

SECTION.




TWO RETORTS
SECTION
FRONT ELEVATION
PLAN OF THE GRATE




SOUTH AMERICA


ISLE
of
DOGS
DEPTFORD
GREENWICH
RAILWAY
1837

SURVEY

OF

THE PORT OF LONDON.

CHAPTER I.

ON THE HISTORY, PRIVILEGES, FUNCTIONS AND GOVERNMENT OF THE PORT.

SECTION 1. *Importance of the Port of London to the whole Empire, and its Rank in the Scale of Commercial Ports.*—2. *Ancient Charters and Authorities.* —3. *Boundaries of its Water jurisdiction.*—4. *Powers, Functions and Privileges of the Corporation, as applying to the Port of London and to the Conservancy of the Thames, and their Title thereto.*—5. *Ancient and present Style of the Corporation of London, and ancient and modern Charters.* 6. *Seizure of the Charters by Charles II., and subsequent Parliamentary Restoration of the same.*—7. *Causes which led to the Appointment of the Corporation of London as Superintendents of the Port, and the Authorities by which they govern the said Port.*—8. *Abstract of the By-laws by which the Port is regulated.*—9. *Constitution of the Port of London Improvement Committee.*—10. *The Officers of the Harbour Service, their Functions and Duties*

§ 1. THE importance of the PORT OF LONDON to the whole Kingdom of England was always so great, that in the earliest periods of English history, the Chief Magistrate of the British Metropolis was called the *Port-gerefa*, or Port-reve, that is, the Steward, Warden or Bailiff of the Port. He obtained this title, not only from being the collector of the King's dues therein, but also as being the Governor of London and its Port. Its value is also acknowledged in the most recent statute of the Legislature relating thereto, 1 and 2 William IV. c. 76, in the following words, quoted from the third charter of James I.—"And whereas it is notoriously known, that the River of Thames is so necessary, commodious and practicable to the City of London, and without the said River our said City could not long subsist, flourish and continue." and it has ever been justly deemed the pride of our Country.

Since those periods, the rise and progress of the commerce and improvements made in the Port of London, have placed it in that proud station which gives it precedence and pre-eminence over every commercial port in the world.

§ 2. King Edward the Confessor, in a charter given by him to the Citizens of London, some fragments of which are extant, addresses it to the *Portgerefa*, a title used in the Saxon times of Hengist; and William the Norman addresses his first charter, previous to 1070, the original of which, in the English language, is preserved among the Corporation muniments in Guildhall, to "William the Bishop and Godfrey the Portreve." Nor was the Norman-French title of *Maire* or Mayor, substituted for the Anglo-Saxon *Portreve* till 1210, in the tenth year of King John, Searle the Mercer and Hugh of Seynt Albon being the last *Portreves*, and Henry Fitz Aleyn or Alwyn, the first Mayor.

§ 3. By King Richard the First's second charter, granted in the eighth year of his reign, the Citizens of London became conservators of the River Thames; and their jurisdiction, partly by prescription and partly by various charters hereinafter mentioned, extends westward of London Bridge to Colnie Ditch, now the River Colne, near Staines, and eastward of the said bridge, over the port and waters of the

Thames, with the ports or creeks of the same, and also over the River Medway, as far as Yantlet Creek, in the county of Kent, and Leigh, in the county of Essex, and from Yantlet, which joins the Thames and Medway, as far up the latter river as Cockham Wood.

§ 4. The Corporation of London, according to the statement delivered to the Dock Committee of the House of Commons, in 1799, as given in the Appendix to the Minutes of that Committee, page 92 *et seq.*, rest their title to the various rights exercised by the City of London, as conservators of the River Thames, upon the following authorities:—1st. On the ground of *prescription*, confirmed by the confession of the Attorney-General, and the judgment of the Court of Exchequer, Trinity Term, 3 James I. 2nd. On *ancient Charters*, particularly those of 8 Richard I.; 1 John; 11 Henry III.; 1 Edward III.; 3 James I.; and 14 Charles II.—3rd. "On *Acts of Parliament*, particularly 17 Richard II. c. 9; 2 Henry VI. c. 15; 4 Henry VII. c. 15; 27 Henry VIII. c. 18; and 14 George III. c. 91.—4th. On *Reports* of Legal Determinations, particularly those in Davis's Reports, 56, 57; Siderfins, 148; 4th Institute, 250.—And lastly, on the exercise of those rights, in a variety of specified instances, which they have arranged under the following heads:—

I. *The right of regulating shipping;* which they exercised, once in 1669, twice in 1710, and once in each of the years 1711, 1721, 1728, 1731 and 1743.

II. *The privilege of fixing posts or piles in the River, for the convenience of shipping;* exercised in 1553, near to the Custom-House, and at the City's expense.

III. *The privilege of removing obstructions, occasioned by weirs and steps;* one instance of which they state as having been exercised in 1559, and another in 1612. To which may be added two other instances, mentioned in Alderman Fabyan's 'Chronicle;' the first being in the Mayoralty of Roger Duke, A.D. 1227, when King Henry III. granted to the City, among many other privileges, "that all werys in Thamys should be plucked uppe and dystroyed for ever;" and the second in the Mayoralty of John Woodcock, Mercer, A.D. 1405, when "the Mayre and his bretherne the Aldermen, as Conservators of the Ryver of Thamys, made suche laboure unto the Kynge" (Henry IV.) "and his counsayll, that they obteyned commission to pull up all the werys that stode atwene London and VII. myle beyond Kyngstown, and in lykewyse for such other as stode atwene London and Gravysende, as wel crekes or several groundes and other; the which commyssion by the sayd Mayre and his officers was this yere put in execution." This was the year before Richard Whittington's second Mayoralty.

IV. *The right of cleansing the River Thames.* One instance of the exercise of this right occurred in 1617, at the expense of £226 16s. 7d.; another in 1624; and the same document states in general terms, "that the City of London have expended, in keeping in repair the avenues of the River Thames, and public stairs and docks, and in cleansing the said River, upon an average of the preceding (to 1799) twenty years, the sum of £6,950 12s. 8d."

V. *The privilege of directing in what places, and the manner in which ballast shall be taken out of the River Thames.* Exercised in 1659.

VI. *The privilege of repairing the banks and breaches of the River Thames.* Exercised in 1572, 1723, on a complaint having been made to the Court of Common Council, and in 1725.

VII. *The privilege of licensing and permitting wharfs, encroachments and other innocent* (innocuous) *projections.* One instance they state to have occurred in the reign of Henry VIII. In 1663, the Corporation appointed a water-bailiff to collect rents for port-galleys, stairs and encroachments. Another instance when they granted permission to the Navy Board in 1788, one to the Trinity House in 1793, and one to the Victualling Board in 1795.

VIII. *The privilege of receiving rents for projections and for innocent encroachments.* Exercised in 1706, when they received a fine of fifty guineas, and an annual rent of £1; in 1724, a yearly rent of £2;

in 1731, a yearly rent of a peppercorn; in 1732, a yearly rent of £4; in 1745, a yearly rent of £3; and in 1762, a yearly rent of £15 15s.

IX. *The privilege of abating or removing wharfs &c., encroaching into the River Thames.* Exercised in 1621, 1681 and 1684. At the Lent Assizes for the county of Surrey, 1786, a cause was tried which lasted three days. It was brought by the Corporation of London as conservators of the River Thames against a shipwright at Rotherhithe, for obstructing the navigation by constructing a floating lock. The jury, after five hours' deliberation, found the defendant guilty, and the nuisance was abated.

X. *The privilege of erecting and maintaining, at the City's expense, public stairs and landing-places.* Exercised in 1669 and 1672.—N.B. The following public stairs were erected and continued to be repaired at the City's expense, namely, those at Billingsgate, London Bridge, Old Swan, Allhallows, Dowgate, Cousin Lane, Queenhithe, Trig Lane, Puddle Dock, Paul's Wharf, Blackfriars and the Temple.

XI. *The privilege of abating or removing stairs and causeways made by individuals.* Exercised in 1680, 1681, 1685 and 1698.

XII. *The privilege of giving orders respecting floats upon the River.* Exercised in 1657, when an order was given to the Water-bailiff to survey the River from time to time, and as often as he found timber fastened or loose, to the hinderance of the common passage of the River, floating on the same, to seize the said timber, and convey it to the Bridge-House, or some other convenient place, and to keep the same until the owner be known, and to pay all the charges; and if no owner appear within a year and a day, then to be sold as other goods and things usually are which are found floating on the River.

XIII. *The privilege of special views.* This privilege was exercised on the 10th January, in the 19th year of Hen. VII. A.D. 1504, John Wyngar, Grocer, being Mayor; when an inquest was appointed of substantial persons dwelling next the Thames, betwixt the Tower and the Temple, and the Aldermen of the wards adjoining the said River, to inquire as to encroachments and defaults made and done on the River Thames, and the viewers of the Court of Conservancy were ordered to go with the inquest and view and rectify all defaults.

XIV. *The privilege of granting licences to erect mills and water-works.* Exercised in 1595, in 1655 when a floating mill on barges was allowed; and when an engine was allowed to be erected against Arundel Wall, to convey water into Covent Garden and its neighbourhood.

XV. *The privilege of holding Courts of Conservancy and punishment of offenders.* The Courts of Conservancy of the River Thames are held periodically by the Lord Mayor, under the authority of a Commission of Conservancy issued by the Crown, at the beginning of each reign. Soon after the Lord Mayor enters upon his office, he appoints the day upon which, during his Mayoralty, he proposes to hold Courts of Conservancy for the several counties of Essex, Kent, Middlesex and Surrey, which appointments are published in the City calendar. Eight courts are holden in the course of a year; two for each of the four counties. Previously to the day appointed for holding a court, the Town-clerk issues a precept from the Mayor to the Sheriff of the county in which the court is to be held, directing him to summon a jury, which is to consist of "forty-four, as well mariners, southsmen, as other persons dwelling in the neighbourhood of the Thames, of which none shall be a fisherman, holder or possessor of any weirs or kiddels in the Thames or Medway; nor have affinity to any such fisherman, holder or possessor." In this precept the duty of the jury is stated to be "to inquire of all transgressions, contempts and offences to the destruction of the fish, and to the impediment of the common passage of the Thames and the Medway." In Surrey the court is always holden in the Town-Hall at Southwark, and in the other counties at some tavern in each which possesses the requisite means of accommodation for the purpose.

After the jury have been called over and sworn, the Recorder, or in his absence, the Town-clerk or the Lord Mayor himself, gives them their charge. Then the Water-bailiff delivers to the foreman the rates for the regulation of the fishery of the Thames, and the court adjourns for about a month, in order to give

the jury time to inquire and prepare their presentments; on this service, which principally refers to the use of illegal nets, the jury are attended and assisted by the Water-bailiff. The Water-bailiff or the jury have power to seize illegal nets when they find them. At the adjourned courts the Recorder attends to receive the presentments, which are publicly read, and afterwards recorded by the Town-clerk; and if, upon consideration, the Lord Mayor is satisfied that they ought to be prosecuted, the City Solicitor is instructed to commence proceedings accordingly.

These Courts of Conservancy, say the Municipal Corporation Commissioners, appear at the present day to be of much less practical importance than formerly; the superintendence of the Navigation and Port of London Committee appointed by the Common-Council having superseded a great part of the duties of the Lord Mayor as conservator of the River Thames. The authority of the Corporation was long and often disputed by the Lord High Admiral of England, and the Constable of the Tower, until the decision of a court of justice and the confirmatory charters of James I. settled the conservatorship of the Thames in the Corporation of London.

XVI. *The privilege of regulating the fishery in the Rivers Thames and Medway.* Exercised under the hereinbefore-mentioned ancient charters, and the more modern provisions of the statute of 30 Geo. II. c. 21.

On a general review of these several rights and privileges, it appears that many of them are more burdensome and expensive to the Corporation than profitable, and ought to be considered as duties towards the public rather than as privileges to be coveted; and perhaps that may be a reason why such a small proportion of the whole catalogue of privileges has been exercised during the last century and a quarter.

In addition to the before-mentioned privileges, the following functions applicable to the trade of the Port of London are vested in the Corporation, in regard to the lading, unlading and storing of merchandise: —

To regulate and control lightermen and watermen in the River, tackle and ticket porters, and in conjunction with Christ's Hospital, the town-carts. To appoint sworn weighers for weighing coals in the Port of London, and to control and regulate in a certain degree this important branch of its trade; also corn, salt, oyster and fruit meters.

By the statutes 39 Geo. III. c. 62 and 10 Geo. IV. c. 124, the Lord Mayor, Aldermen and Commons in Common-Council assembled are empowered to make by-laws for the government of the Harbour-masters of the Port of London, which by-laws, by the first-mentioned statute, are required to be sent to the Trinity House for perusal before being allowed by the judges, to give the Elder Brethren an opportunity of submitting their objections, if any, to such by-laws.

The appointment of the Harbour-masters is in the Lord Mayor as conservator of the Thames, but no person can be appointed by the Lord Mayor to execute the office of Harbour-master unless he shall, after being duly examined by the Master, Wardens and Assistants of the Trinity House, produce a certificate from them of his proper qualification to execute the office.

§ 5. The most ancient style of the Corporation of the City of London, was *the Portgerefa and Burwara*, or burghers, *of London*, and lastly through many variations the *Mayor and Commonalty of London*, which is the style by which they are now designated.

London is not mentioned in Domesday, but the before-mentioned charter of William the Conqueror recognised the Corporation as an ancient and subsisting community; as does also the second charter of King Richard the First. The second charter of King John, given the first year of his reign, grants for the benefit of the City of London and of all the realm, not only a power to remove all weirs and obstructions in the Thames and Medway, but also a right to inflict a penalty of ten pounds on such persons as offend

by erecting them. The 15th section of Magna Charta confirms to the City of London all its ancient liberties and free customs, as well by land as by water.* By the third charter of King Edward the Third, granted with the consent of Parliament held at York in the 11th year of his reign, any infringement of the privileges of London was to be considered as in contravention of Magna Charta; and as Magna Charta being afterwards exemplified and confirmed as a City charter by Henry the Fourth, and afterwards by Henry the Sixth and Edward the Fourth, which are authentic instruments issued at periods when charters were not obtained without much consideration on the part of the Crown, it is properly considered as a charter containing a special grant to the City of London of all its privileges, as well by land as by water. Many other charters also, copies of which were delivered to the Select Committee of the House of Commons appointed in 1820 to inquire into the state of London Bridge, and are printed in its Report, confirm all these privileges to their fullest extent. A charter granted by Edward the Fourth, dated the 25th March, in the second year of his reign, exemplifies and ratifies the charter of Henry the Fourth, dated the 25th May, in the first year of his reign; and Magna Charta being exemplified in both, is thus farther proved to be essentially a City charter.

The charters of Mary and Elizabeth confer no additional privileges, being merely charters of inspeximus and confirmation, as are those of Henry the Eighth; but the first charter of King James the First, dated the 20th August, in the third year of his reign, A.D. 1606, is addressed to "our beloved the Mayor and Commonalty and Citizens of our City of London." In this charter is an acknowledgment from the Crown, that they have, from time out of mind, exercised the office of bailiff and conservator of the water of Thames; the same to be exercised and occupied by the Mayor of the same City, for the time being, during the time of his Mayoralty, or by his sufficient deputies, in, upon and about the water of Thames. That is to say, from the bridge of the town of Staines, in the county of Middlesex, and towards the east unto London Bridge, and from thence to a certain place called Kendall, otherways Yenland, otherways Yenlett, towards the sea and east, and in Medway, and in the PORT OF LONDON aforesaid, and upon whatsoever bank, and upon every shore, and upon every wharf of the said water of Thames within the limits and bounds aforesaid, and in and upon and about all and every of them; and also for all the time aforesaid have had and taken, and are to have and take, to their own proper use, by the Mayor of the same City for the time being, during the time of his Mayoralty, or by his sufficient deputies, all wages, rewards, fees and profits belonging to the same office of bailiff. He also acknowledges that they had a prescriptive right to exercise the office of meter and metage of all coals, grain, salt, fruit, eatable roots &c., and of all other merchandises, wares and things measurable, and the measuring of every of them, in or unto the said Port of London, coming, carried or brought upon the said waters. Two other charters of James explain and confirm these rights and privileges.

The first charter of King Charles the First, dated 18th October, 1638, in the fourteenth year of his reign, contains a general exemplification and confirmation in the most extensive terms of all preceding charters. It also grants to the Corporation all the messuages, houses, edifices, cottages, buildings, courts, yards, gardens, shops, sheds, stables &c. &c. &c., and the ground and foundations of them, easements and appurtenances, which had been made or erected upon the waste grounds, streets or ways in the City, or *on the river or water of Thames, or upon the ports, banks, creeks or shores of the same, within the City or its liberties.*

The second charter of Charles the First, dated the 5th September, in the sixteenth year of his reign, states, that whereas the Mayor, Commonalty and Citizens of the City of London, and their predecessors, *within the Port of London,* were entitled to certain dues called package and scavage from foreigners, and as doubts had arisen thereon it explains and confirms them. These duties of package, baillage and scavage were collected in the Port of London till they were recently extinguished, by the purchase thereof, made by Government under the statute of the 3rd and 4th William the Fourth.

The last general charter which concerns the Port of London was granted by Charles the Second, dated the 24th June, in the fifteenth year of his reign, and is an inspeximus and confirmation of William

* "Ut Civitas London plene habeat antiquas libertates et liberas consuetudines suas, tam per aquas quam per terras."

the Conqueror's charter, Charles the First's first charter, including all those charters which are confirmed therein, in the same manner as if they were exemplified in chief; and also the second charter of Charles the First.

§ 6. After a lapse of twenty years from the foregoing confirmation of the same, the Citizens of London were induced to oppose the succession of James Duke of York to the Crown of England. James was an open and avowed enemy of the Protestant religion and liberty, and was at that time labouring with uncommon energy to set up Papacy and oppression in their places. This opposition on the part of the Citizens of London brought on them the resentment of the hypocritical King, his bigoted brother and the Court, who ordered a commission to be issued to try certain persons who had at the last election for sheriffs acted, as the words of the commission state, in a riotous and unlawful manner. In consequence thereof fourteen gentlemen, principally Aldermen, who were supporters of the Protestant cause, were tried and condemned in heavy fines. After this stretch of power the King ordered a writ *Quo warranto* to be brought against the City by his Attorney-General in Michaelmas Term 1682, and in Hilary and Easter Terms 1683, and in Trinity Term next following.

The Judges, Jones, Raymond and Withers, pronounced the judgment of the Court—"That the franchises of the City of London should be seized into the King's hands."

Thus were the Citizens deprived of their liberties by an arbitrary King, through the instrumentality of his revengeful brother. The triumph however was but of short duration, for Charles dying in February 1685, was succeeded by the bigoted and gloomy-minded James, whose endeavours to re-establish Popery in England were so precipitate as to be the occasion of his overthrow. The nation at large, groaning under his oppressive despotism, determined to enjoy their former laws and liberties or die in their defence. Several worthy patriots, both in and out of the City, zealous in the Protestant cause, came to the resolution of inviting the Prince of Orange, who was the King's son-in-law, to England, to defend their country from Popish subjection, to which the laws and religion of England would otherwise have been subjected.

James, no sooner heard of the intention of the Prince to come to England, than he promised the Citizens a restoration of their charter, and finding affairs hastening towards a crisis, sent on the 6th October the Lord Chancellor Jefferies with the City charters, and two grants under the great seal for restoring the same. These he delivered to the Court of Custos and Assistants, the substitutes for the Mayor and Aldermen, then sitting in the Council-Chamber in Guildhall. Shortly after this act of justice, the pusillanimous tyrant abandoned his throne and fled his country. The people of England, in 1690, raised his daughter, Princess Mary, and her husband, the Prince of Orange, to the throne, under the titles of King William III. and Queen Mary II., who by an Act of Parliament, passed in the second year of their reign, reversed the judgment obtained on the before-mentioned writ of *Quo warranto*, and restored the City and its Port to all its ancient functions, rights and privileges.

Under this and other Parliamentary confirmations of the City franchises, it is the opinion of the law-officers of the City, that no Act of Parliament affects the City customs, unless the City be particularly named therein, so as to be *pro tanto* a repeal of the statutes continuing the City's rights. Thus they hold that, as wager of law was received in the City courts, by virtue of a peculiar custom, under regulations different from those which prevailed at common law, the statute abolishing this mode of trial does not affect the custom of law in the City.

The last charter obtained by the City was granted by George the Second, and is dated the 5th August, in the fifteenth year of his reign. It recites the substance of the charter of William and Mary, and confirms all the preceding.

§ 7. The causes which led to the appointment of the Corporation of London as superintendents of the Port of London in addition to those of the above bridge navigation, and the conservancy of the water of Thames and Medway, arose from the following circumstances.

In consequence of the crowded state of the pools, inquiries were instituted in 1792; Committees of both Houses of Parliament were appointed to inquire into the best mode of providing sufficient accommodation for the increased trade and shipping of the Port of London &c. &c. The Report of this Committee, which was printed by the order of the House of Commons, occupied between four and five hundred pages, and many engraved plans of improvements suggested by the first architects and engineers of the day; and the evils complained of may be referred to four great and principal sources, namely:—

1st. The inadequacy in point of extent of the legal quays, which were not of greater extent than they were in the year 1666.

2nd. The crowded and obstructed state of the River.

3rd. The want of a proper arrangement and distribution of the business on the quays.

4th. The want of a well-ordered system in the disposition of vessels in the River, and in the management of lighters and craft.

There were also other secondary and subordinate causes which contributed to the grievance in question, which are not worth reviving, but may be found at length in the before-mentioned Report, Evidence and Appendix.

The result of this important inquiry was the passing of an Act of Parliament in 1799, 39th Geo. III. c. 69, entitled "An Act for rendering more commodious and for better regulating the Port of London;" generally known by the name of the Wet-dock Act, which gave the present extensive powers, functions and privileges to the Corporation over the Harbour and Port of London.

The present authorities who exercise powers and functions in the Port of London, are—1st. Her Majesty, as lord of the soil of the River, which in certain respects is now delegated to the Corporation of London. Her Majesty in Council appears however to have extra powers as regards foreign vessels in time of war, and in respect to Her Majesty's ships. The former privilege was exercised in 1797, when all foreign vessels were ordered not to approach the Metropolis higher than Limehouse; and the latter, by His late Majesty when Duke of Clarence and Lord High Admiral of the United Kingdom of Great Britain, who issued rules, orders and regulations for mooring ships in the River Thames, at Deptford, Woolwich and Greenhithe, bearing date June 27, 1827, and under the authority of an Act of Parliament of the 54th Geo. III. c. 159.

2nd. The Lord Mayor of London as Conservator of the River and the Corporation. By virtue of the authority of the before-mentioned Act for rendering more commodious and for better regulating the Port of London, and of the Acts of 10 Geo. IV. c. 126, for altering and amending the preceding, which repeals so much of 39 Geo. III. c. 69, as relates to the City Canal, and provides for the sale thereof to the West India Dock Company, who are now the proprietors, and of the 4th and 5th Will. IV. c. 32, which provides for a reduction in the amount of the Port dues, the present Committee of Management are appointed and derive their powers.

3rd. The Corporation of the Trinity House of Deptford Strond; who exercise certain functions and duties under the authority of Royal Charters and Acts of Parliament, as hereinafter described in the second chapter.

4th. The West India and other Dock Companies; who have certain powers and jurisdictions conferred upon them; the former by the before-mentioned Act for better regulating the Port of London, and the others, which are hereinafter enumerated and described in the second chapter, by their own several Acts of Parliament.

5th. The Commissioners of Her Majesty's Customs; who by themselves and their officers, under the

authority of Parliament, make and enforce rules, orders and regulations, respecting the security and the collection of the public revenue.

6th. The Lord Mayor and Aldermen as magistrates in the City, and Her Majesty's other Justices of the Peace, under the Police Act; who take cognizance of felonies, larcenies and misdemeanors, committed within their respective jurisdictions.

It is by the general operation of these several authorities,* that the government of the Port of London is now carried on, in the manner and by the functionaries hereinafter described.

By these authorities, power is granted to the Lord Mayor, for the time being, as Conservator of the River Thames, to appoint harbour-masters for the Port of London, subject to their qualifications being first approved by the Elder Brethren of the Trinity House Corporation. In consequence of the surrender of the right exercised by the Crown and its grantees Lord Gwydir and others as to the rents and profits of the mooring-chains in the River, which was enjoyed by virtue of a lease or patent from the Crown, compensations for which were made under the direction of Commissioners, the Act places the whole of the said moorings under the Corporation of London.

The 108th section of the said Act authorizes the Lord Mayor, Aldermen and Common-Council to make by-laws, rules, orders and regulations, for the good government of the harbour-masters, and other persons employed under the Act, by the Corporation;—for regulating the works &c. to be made by them, while making and when completed;—for the more safe and convenient navigating, placing, mooring and unmooring ships and other vessels in the River Thames &c. (Docks &c. excepted, as described in the second chapter);—for the better governing and regulating all masters of vessels, pilots, lightermen and others, within the said Port, and its appurtenances;—for preventing damage being done to shipping, lighters and craft, or to any goods, wares or merchandise; and such other by-laws as they shall deem necessary and expedient, so as the same shall not be inconsistent with that or any other Act. Also, to repeal and alter the same by-laws, and to affix reasonable penalties for non-observance thereof.

The said Act and section also enacts, that the said by-laws are to be printed and distributed in the Port of London; but by section 111, they are not to be valid nor put in force until allowed and approved of by the Lord Chancellor, two Chief Justices of the Queen's Bench and Common Pleas, and the Lord Chief Baron of the Exchequer, or any one or more of them. Also, by section 112, thirty days before these by-laws shall be allowed by the Judges, a copy of them is to be submitted to the Trinity House, who may state their objections, if any, to the Lord Mayor and Corporation; and if not satisfied with their decision, they may then state such objections to the Judges before the said by-laws are allowed. By section 108, the penalties inflicted under the authority of these by-laws are recoverable by distress and sale, by warrant of any one Justice of the Peace, within whose jurisdiction the offences are committed; who, if the penalties are not paid, may commit the offender for twenty days, or until payment of the same.

The present " By-laws for the government of the harbour-masters, and for regulating the Port of London, and which repealed those made in Alderman Thompson's Mayoralty in 1829, were passed" at a Court of Common-Council, held in the Chamber of the Guildhall of the City of London, on Thursday, the 1st of December, 1836, in the seventh year of the reign of William the Fourth, of the United Kingdom of *Great Britain* and *Ireland* King, Defender of the Faith; before the Right Honourable Thomas Kelly, Esq., Lord Mayor, *Sir Claudius Stephen Hunter*, Baronet, *Anthony Brown*, Esq., *Sir*

* The Select Committee of the House of Commons, appointed to inquire into the state of the Port of London, in their Report printed by order of the Honourable House, August 12, 1836 —"are of opinion, that the various conflicting jurisdictions and claims of the Admiralty, the Trinity House and the Corporation of London over the River Thames below the bridges, have had a most injurious effect upon the interests of navigation, and that it is desirable that they should be consolidated and vested in some one responsible body, and that means should be found to provide for the removal of shoals and obstructions in the bed of the River."

Peter Laurie, Knight, *Charles Farebrother*, Esq., *Henry Winchester*, Esq., *John Cowan*, Esq., *Samuel Wilson*, Esq., *James Harmer*, Esq., *Thomas Johnson*, Esq., *Thomas Wood*, Esq., *James White*, Esq., Aldermen of the same City, and the greater part of the Commons of the said City in the same Common-Council then and there assembled.

They are entitled, "By-laws, Rules, Orders and Regulations, for the good government of the Harbour-masters of the Port of London, and for the more safe and convenient navigating, placing, mooring, unmooring and removing of ships and other vessels, steam-boats, lighters and craft on the River Thames, in and near the said Port, and for other purposes; made, ordained and established, this First day of December, One thousand eight hundred and thirty-six, by the Mayor, Aldermen and Commons of the City of London, in Common-Council assembled, in pursuance and under the authority of an Act of Parliament passed in the tenth year of his late Majesty King George the Fourth, intituled '*An Act for altering and amending* the powers of an Act of the thirty-ninth year of the reign of King George the Third, for rendering more commodious and for better regulating the Port of London.'"

This Act, authorizing the Corporation of London to make by-laws for the government of their own Port, seems almost to be a work of supererogation, unless lawyers deem such repetitions to be exemplifications and confirmations. For the power of making by-laws, contained in the before-mentioned charter of the 15 Edw. III. has been solemnly adjudged to extend to the making of by-laws or ordinances which are against common right and the rules of the common law; in the case of the City of London, 8 Rep. 121 *b. Hutchins* v. *Player*, O. Bridgeman, 272; but it is to be observed, that in both these cases the power was laid as a custom, confirmed by authority of Parliament 7 Rich. II., meaning the last charter, although the charter of the 15 Edw. III., containing, as before mentioned, a grant of this power, also appeared on the pleadings; at any rate in the earlier of these two cases, being recited in an act of Common-Council set forth in the return to the writ Habeas Corpus.

In the latter case, Sir Orlando Bridgeman, Chief Justice of the Common Pleas, in a very elaborate judgment, quoted by the learned Commissioners of Inquiry into the Municipal Corporations of England and Wales, in their second Report, copied from his own manuscript now extant, expressed himself in the strongest terms in giving the most extended construction to the power. "It is the foundation," he says, "of most of the ordinances now in force in London for the government of the City; which would be shaken if you take away this pillar, and leave to London no more power touching by-laws than you do to every ordinary corporation or company." And then he proceeds to show, that various ordinances declared to be good could not, as he alleges, be otherwise supported in law.

These by-laws, then, being so triply armed, recite in the first section, after the usual preamble, that "whereas it is deemed meet and requisite by the said Mayor, Aldermen and Commons in Common-Council assembled, under the authority of the last-mentioned Act, to repeal the said last-mentioned by-laws (of the 14th July, 1829, Thompson Mayor), rules, orders and regulations, and to make, ordain and establish others in lieu thereof." These by-laws were ordered and established, according to the Act of Parliament, by Court of Common-Council, having been drawn up by the Port of London Improvement Committee, assisted by the professional officers of the harbour service. They therefore under the said authority repeal the former by-laws, announce and publish the new, as *the code of laws of the Port of London*, with the necessary fiats of the Master, Wardens and Assistants of the guild, fraternity or brotherhood of the most glorious and undivided Trinity, and of St. Clement, in the parish of Deptford-Strond, in the county of Kent, who according do allow and approve of the said by-laws, rules, orders and regulations. In testimony of which they caused their common seal to be thereunto affixed the Sixth day of December, One thousand eight hundred and thirty-six.

The necessary Judge's fiat is—"I have perused and examined these by-laws, rules, orders and regulations, and do allow and approve of the same. Dated this Sixteenth day of January, One thousand eight hundred and thirty-seven.

"N. C. TINDAL."

§ 8. These* by-laws having therefore been printed, distributed and affixed in manner required and directed by the before-mentioned statute, became from the 1st March, 1837, the laws, orders and regulations of the Port of London.

The 1st section defines the powers of the Harbour-masters. Such one of the four Harbour-masters as shall be from time to time appointed principal or superintending Harbour-master, is to have the sole and entire control of the executive part of the harbour and mooring-chain service, and is to be responsible for the due performance of the whole of such service, and is to give such orders and directions to the other Harbour-masters as he shall from time to time deem necessary, provided the same be in accordance with the spirit and intent of the said Acts of Parliament, and the by-laws and regulations established under the authority thereof.

By the 2nd section, the three other Harbour-masters under the general superintendence of the principal, are to discharge the duties and reside within the limits of particular stations to be from time to time severally allotted to them by the said Committee, which stations are therein ordered to be as follows. *(See the larger Chart, Plate 1.)* The *first* or upper station extends from London Bridge to Wapping Dock Stairs, and the Harbour-master appointed to such station is to reside at the Harbour-masters' Office, by St. Katherine's Stairs, within the limits of that station. The *second* or central station extends from Wapping Dock Stairs to Limehouse Stairs; and the *third* or lower station extends from Limehouse Stairs to Bugsby's Hole, and the Harbour-master appointed to such third station is to reside at the Harbour-masters' Office, within the limits of that station.

By the 3rd section each of the said four Harbour-masters are to be provided with a boat and a competent number of watermen. That the boat of the principal Harbour-master is to be distinguished, when on duty, by a small flag, with the *Merchants' Union Jack;* that of upper station Harbour-master, by a *red* flag; that of the central station, by a *blue* flag; and that of the lower station, by a *white* flag.

By the 4th section, the aforesaid watermen are also to reside within their particular stations, and may be suspended for misconduct by the Harbour-masters.

The 5th section enacts, that the Harbour-masters are to attend the meetings of the Committee when summoned; the 6th, that the stationed Harbour-masters are to be under the order of the principal; the 7th provides for accidental absences of either of the Harbour-masters; the 8th, that appeal may be made to the Committee against the orders of the principal Harbour-masters, if thought to be objectionable; the 9th, for occasional leave of absence; the 10th, for their proceedings to be entered into books; the 11th, for Reports to the principal from the stationed Harbour-masters; the 12th, that the Harbour-masters are not to be concerned in any other business or profession; the 13th, that the stationed Harbour-masters are to take soundings of the River, within the limits of their respective stations, from time to time, according to the Trinity House standard, and to report the same, upon pain of suspension or dismissal, and are to make such returns of ships, and keep such books and accounts, as the Committee may require; the 14th, that the Harbour-masters &c. are not to receive any gratuity under pain of immediate dismissal; the 15th, that they are not to show any partiality in mooring ships &c.; the 16th enacts, that "for the purpose of preserving a free passage between *Iron Gate Stairs* and *Bugsby's Hole (see larger Chart)*, of sufficient width that ships, vessels, and steam-boats of large dimensions and draught of water may navigate up and down the same without impediment or risk, it is further ordained and established by the authority aforesaid, that the width of such passage, except only when rendered impracticable by unavoidable casualties, shall not be less than three hundred feet," and defines the mode of admeasurement to be in the clear between the tiers of moored ships. The 17th section enacts, that the Harbour-masters are to provide accommodation for shipping between London Bridge and Iron Gate Stairs, and to maintain in that portion of the River a passage of two hundred feet.

* Copies of these by laws can be obtained at the Upper Station Harbour-masters' Office, at St. Katherine's.

The 18th section apportions certain tiers and moorings in the Port of London for the exclusive use of collier ships or vessels, which are to be moored as near to the respective shores as the depth of the water will permit, and that no more collier ships or vessels shall be permitted to be and remain placed, moored, and distributed thereat at one and the same time, than the number hereafter respectively specified; that is to say *(see larger Chart)*,

On the North side of the said River—

At *Coles Stairs* tier, not more than ten ships to be moored with their heads up the River, and ten ships to be moored with their heads down the River.

At *Bell Wharf* tier, not more than ten ships up and ten ships down.

At *Stone Stairs* tier, not more than nine ships up and nine ships down.

At *Ratcliff Cross* upper tier, not more than eight ships up and eight ships down

At *Ratcliff Cross* lower tier, not more than eight up and seven down.

On the South side of the said River—

At *Hanover Hole* lower tier, not more than ten ships up and ten down.

At *Mill Hole* upper tier, not more than ten ships up and ten down.

At *Mill Hole* lower tier, not more than nine ships up and nine down

For the manner of mooring these vessels, see Plate 18.

Section 19 enacts, that no colliers are to be anchored between the tiers or in the navigable waterway; the 20th, that the Harbour-masters are to detain between Limehouse and Bugsby's Hole all vessels, coal laden or partly coal laden, from entering the Pools, and to cause a flag, half red and half white, to be hoisted at the Lower Station Office, whenever the Harbour-masters shall think that no more such vessels should proceed higher up the River then Limehouse, under a penalty of ten pounds for infringing such order; the 21st, that the Harbour-masters are to give notice for the removal of any ship &c. which may be so moored as to encroach upon the before-mentioned passage, and in case such notice is not complied with, they are to employ persons to remove the same under the penalty of ten pounds, and the expenses of such removal to be paid by the person in command, or the owner; the 22nd inflicts a penalty of five pounds and expenses, to be paid by owner or person in charge, for mooring ships, timber &c. in any of the in-shore passages or ferries between London Bridge and Limehouse, so as to obstruct the transit thereof; and by the 23rd section, no raft of timber exceeding sixty feet in length and twenty feet in breadth is to pass along the stream between Limehouse Hole and London Bridge, and no such raft exceeding forty feet in width is to pass along any other part of the stream, between Limehouse Hole and the lower part of Bugsby's Hole, nor two or more rafts to go abreast, nor more than three lengthways, nor any following raft to go within three hundred yards of each other, under a penalty of five pounds. The 24th section directs, that barges are to pass singly under a penalty of forty shillings; and by the 25th, every barge &c. is to have one able and skilful man at least always on board, under a penalty of forty shillings, and if left without any hand, another penalty of forty shillings. By the 27th section it is ordered, that anchors are not to lie or remain in the stream to endanger ships &c. under a penalty of five pounds; and the Harbour-masters are to remove such anchors at the owners' expense, under a penalty of five pounds. The 28th section enacts, that no ship &c. be navigated or lie, between Bugsby's Hole, with its anchor, or anchor a-cock-bill, that is to say, hanging perpendicularly by the stopper from the cat-head, except while in the act of fishing the same, or during such time as may be absolutely necessary for getting such ship &c. underway, or bringing her to anchor, under a penalty for such offence of five

pounds, and for every such anchor so carried, shall forfeit and pay the further sum of forty shillings; and by the 29th section, no ship &c. is to be navigated with its anchor hanging by the cable, except during such time as may be necessary for catting and fishing, under a penalty of five pounds. By the 30th section, ships &c. are to be slacked off when required by the Harbour-master under a penalty of five pounds for not obeying such order; by the 31st, ships are not to be boomed off, unless to admit lighters; and when in tier they are to be laded over the bows, unless from weight or bulk it may be necessary to load alongside, and masters of ships &c. are to be obey the directions of the Harbour-master or pay a penalty of forty shillings; by the 32nd, ships &c. moored across the River with hawser or rope, between London Bridge and Bugsby's Hole, are to slack the same down when other vessels are going down, or pay a penalty of five pounds.

The 33rd section, that if any person whatever shall in any way obstruct the Harbour-masters in the execution of their duty, or threatening them, shall forfeit for every such offence ten pounds; the 34th orders, that yards and topmasts are to be struck when necessary for general safety, under a penalty, for disobedience, of forty shillings.

The 35th and last section provides, that nothing contained in the said by-laws &c. "shall extend, or be meant to extend, to give to the Harbour-masters, or any or either of them, any power or authority whatsoever over any dock or docks with their appurtenances, or within the limits *(see larger Chart)* adjoining to the said dock or docks in the said River, or such parts of the said River as are within the respective distances prescribed by any Act or Acts of Parliament for establishing such dock or docks; or over any ship, vessel, steam-boat, lighter or craft belonging to the Corporation of the Trinity House of Deptford-Strond, or in any manner whatsoever to effect any of the rights or privileges belonging to the same; or to prevent the Lord High Admiral of Great Britain, or the Commissioners for the time being for executing the said office, from laying chains or other things for mooring or stationing ships or vessels belonging to Her Majesty in any part of the said River and Port below the dock called Greenland Dock, as the said Lord High Admiral or Commissioners shall from time to time think proper; or to prejudice any of the rights, interests, privileges, or franchises or authority of the Lord Mayor of the said City of London for the time being, or to defeat or alter any power, authority or jurisdiction which he may or otherwise might lawfully claim, use, or exercise as Conservator of the River of Thames and Waters of Medway, but the same are severally exempted therefrom.

"WOODTHORPE."

§ 9. By the 64th section of the before-mentioned Act for rendering more commodious, and for better regulating the Port of London, the Corporation of the City of London are empowered to appoint Committees to carry the provisions of the Act into effect; and a Committee, which was, till the Act of the 10 Geo. IV. c. 130, called The Port of London Improvement Committee, but which was then merged into the Navigation Committee, and now called "The Navigation and Port of London Committee," is annually appointed at the first meeting of the Common-Council after Plough Monday. This mixed Committee being intrusted also with the execution of duties and management relating to the Thames navigation above London Bridge, under particular Acts of Parliament relating to that branch of the City's jurisdiction.

The Thames Navigation and Port of London Grand Committee consists of the Lord Mayor for the time being, its nominal chairman, fifteen other Aldermen, and thirty Common-Councilmen. The Lord Mayor seldom attends the Committee, but approves of a chairman elected by the Committee from among the Commoners, who is generally one of those in the fourth or last year of his service, as all the members go out in rotation after having served that period. Any two Aldermen and four Commoners, or any seven members, are a quorum. The Town-clerk is clerk to the Committee. The *Sub-Committee* consists of all the Aldermen present at its monthly nomination, and eight Commoners besides the chairman. All the members go out at the end of each month, and fresh Commoners are chosen in the alphabetical order of the Wards of the members present. Three make a quorum. If any urgent business be in progress at the time of the renewal of the Sub-Committee, it is usual to appoint the last Sub-Committee to be a Special Committee, there being no regular Special Committee. The meetings of the grand and subordinate

Committees are in numbers from fifty to sixty in a year, and from twenty to thirty members, on an average, attend the Grand Committee, which meets on the first Thursday after Plough Monday in January, and on the first Thursday in every other month.

This Committee superintends the conservancy and navigation of the Thames from Yantlet Creek up to Staines, the River Medway up to Cockham Wood, and the River Lea up to Temple Mills; and fulfils in some measure the duties of the Water-bailiff. By the before-mentioned Acts of the 39 Geo. III. c. 69, and the 10 Geo. IV. c. 24, the regulation of the Port of London, which extends from London Bridge to Bugsby's Hole, as delineated in the larger Chart, is intrusted to the Corporation, and by them, as hereinbefore-mentioned, to this Committee; which in this character apply the money annually granted by Parliament out of the tonnage duty for the harbour service of the Port of London, and pay the surplus into the Consolidated Fund.

The important nature of the business intrusted to this Committee, renders it necessary for them to act in many instances with promptitude, and they are therefore invested with fuller powers from the Corporation in the first instance, without reference to the Common-Council, than other Committees. These include, for instance, grants of accommodation to parties requesting leave to drive piles, or to construct works on the banks of the River. The Harbour-masters, by the same statutes, are under the direction of any Committee appointed for that purpose by the Common-Council, who have hitherto, as before mentioned, appointed this Committee, which also superintends the collection of tolls upon the River, and appoints the collectors.

§ 10. The officers of this Committee and their functions, taken principally from and in the rotation given in the second Report of the Commissioners appointed to inquire into the Municipal Corporations of England and Wales, and ordered by the House of Commons to be printed the 25th April, 1837, to which, and to the Report of the Select Committee of the House of Commons, ordered to be printed the 12th August, 1836, I am indebted for much valuable and hitherto unpublished information, are as follow:—

The Surveyor of the Port of London, whose duties are to prepare particulars and specifications for contracts, and to certify quantity and amounts; to advise with the Superintendent of the mooring-chains, when required, in respect of alterations to be made in any of the moorings in the River, or of additional ones to be laid down, and to prepare the estimates, particulars and specifications for contracts for mooring-chains, anchors &c. He also attends the Board of Harbour-masters when required, has an office in the City, where he can be referred to, and attends the Committee at their meetings when summoned, and performs any other duty that may be required of him as a Surveyor, in respect of any buildings belonging to the Committee.

This officer is elected by the Committee under the authority of the Port of London Act; and the present holder thereof, according to the evidence of the Town-clerk given before the Commissioners, is an Architect and Civil Engineer, and produced testimonials at the election, which was a contested one in 1828, of his qualifications in both professions.

The present Surveyor is Mr. James Elmes, and his before-mentioned office for the City is at No. 9, St. Bride's Avenue, Fleet Street; and for the West-end, No. 11, Park Street, Westminster.

The Principal or Superintending Harbour-master.

The duties of this officer are, as detailed in the by-laws, to superintend and direct daily the entering, mooring, unmooring, moving and removing of all ships and vessels, steam-boats, lighters and craft coming into the Port of London &c., as hereinbefore more fully detailed in the 1st section of the by-laws.

The present Principal Harbour-master is John Fisher, Esq., a Captain in the Royal Navy, who was appointed Harbour-master, according to the provisions of the Port of London Act, in June 1819, by the then Lord Mayor, Alderman Atkins.

The election of all the Harbour-masters is governed by the same statute. The Lord Mayor, on a vacancy, appoints some person who can produce a certificate of qualification from the Elder Brethren of the Trinity House. The usual practice is for the Lord Mayor to make up his mind in the first place as to the appointment, and then for the person, in favour of whom he has decided, to undergo the examination.

The new Harbour-master then receives an appointment under the hand and seal of the Lord Mayor. Formerly the Harbour-masters took precedence by the dates of their appointments, as do the present four, who were all appointed before the amended Act of the 10th Geo. IV. c. 124, was passed, by the 11th section of which, the Common-Council, or any Committee appointed by them, may determine which of the four is to be the principal, the remaining three to take rank as at present.

The three stationed Harbour-masters.

The duties and functions of these three officers are also hereinbefore described in the 2nd and 3rd sections of the by-laws.

The present Upper Station Harbour-master is William Cousins, Esq., formerly an officer in the Navy of the Honourable East India Company, who received his appointment in September 1820, and resides at the office in St. Katherine's. The present Lower Station Harbour-master is Charles Rowland, Esq., of the same service, who was appointed August 1821, and resides at the Lower Office at Greenwich.

The present Central Station Harbour-master is William Mayott, Esq., a Lieutenant in the Royal Navy, who received his appointment in September 1829, and resides at Greenwich.

Superintendent of Mooring-chains.

The duties and functions of this officer comprehend the superintendence of the repairs or alteration of all the mooring-chains, mooring-anchors, mooring-stones and buoys in the Port of London, belonging to the Corporation, and to lay down any new moorings that may be required from time to time.

To keep an account of the wages and expenses attending the office, and, in conjunction with the Surveyor of the Port, of the repairs necessary to the buoys; to lay both books before the Committee when required, and the accounts for examination and audit at the first meeting of the Committee after every quarter-day; and also to keep an account of serviceable and unserviceable stores belonging to the harbour service of the Port of London. To make a Monthly Report in writing of all the work that has been performed, which, signed by the Principal Harbour-master, is to be laid before the Grand Committee at their monthly meeting. To keep a book at the office at St. Katherine's, and enter daily an account of what work has been performed, and where that work is situated; also to report to the Principal Harbour-master and Surveyor of the Port, when any of the chains, anchors, stones and buoys are under repair, and the probable time it will take before such work is completed; and to attend the Port of London Committee whenever summoned.

The present Superintendent of mooring-chains is Mr. Matthew Marshall, who was elected to the office on the death of his father, in 1813. He resides at No. 7, Lucas Street, Rotherhithe, has his office at that of the Upper Station, St. Katherine's, and a wharf for mooring-stores, and a counting-house at Cherry Garden Stairs, Rotherhithe. He gives security to the amount of £200.

This officer is elected under the authority of the Port of London Acts by the Committee, in the same manner as the Surveyor and Clerk; the powers of election and dismissal are in the Common-Council, who execute them through the Navigation and Port of London Committee.

The right of superintending the mooring-chains was formerly in Lord Gwydir, by a grant from the Crown, but it was purchased from him and the Crown in 1800.

Clerk to the Harbour-masters.

The duties of this officer are, to attend at the Upper Station Office, St. Katherine's, daily from nine o'clock in the morning until five o'clock in the afternoon; to keep the several books, registers and daily entries of shipping, and the accounts of the harbour service. To answer all inquiries that may be made by merchants and others, relative to the shipping in the Port of London; to receive all communications and complaints made at the office, by masters of vessels and others, during the unavoidable absence of the Upper Station Harbour-master on his River duties; to pay the weekly wages of the watermen belonging to the harbour service, and the various allowances and expenses incurred in carrying that service into execution; to keep correct accounts of the same, and to have them regularly examined and audited, once in every quarter, by the Port of London Improvement Committee; to attend the said Committee whenever summoned, and to be subject to such rules, orders and regulations, as that Committee may from time to time direct.

The present holder of this office is Mr. Malcolm Dunnett, Junior, who was elected by the Committee, in 1827. He gives security for £200. The election to this office is under the authority of the Port of London Acts by the Committee, in the same manner as the Surveyor and the Superintendent of mooring-chains.

CHAPTER II.

ON THE EXTENT, DIVISIONS AND COMMERCIAL REGULATIONS OF THE PORT.

Section 1.—*Its Extent.*—2. *Its Divisions.*—3. *Its Soundings, Widths and Distances.*—4. *Its Shoals, Banks, and other Impediments to Navigation.*—5. *By whom, and at whose expense these Shoals, Banks and other Impediments are and ought to be removed, and the Reasons assigned by the Corporation of the Trinity House for not removing them.*—6. *Sketch of the Rise and Progress of its Commerce, and the Commercial Bodies connected with the Port.*—7. *The several Dock Companies &c. in the Port.*—8. *Account of the number of vessels that can be accommodated in the Port of London, according to the present By-laws.*—9. *Dues, Charges &c. in the Port of London.*—10. *Summary of the Rights, Privileges, Functions, Powers and Jurisdictions of the Corporation of London, over its own Harbour and River.*

§ 1. The extent and limits of th Port of London, as relates to Her Majesty's customs, is declared by the Court of Exchequer to extend and to be accounted from the promontory or point called *the North Foreland*, in the Isle of Thanet, then northward in an imaginary line drawn to the opposite promontory or point, called *the Naze*, on the coast of Essex, through the Gunfleet Beacon, and so continuing westward up the Thames, and the several channels, streams and tributary rivers falling into it, as high up as London Bridge; save and except the usual and known right, liberty and privileges of the Ports of Sandwich and Ipswich, and the known members or appurtenances thereof, and of the customers, comptrollers, searchers and other deputies of and within the said Ports of Sandwich and Ipswich, and the several creeks, harbours and havens to them or either of them respectively belonging within the counties of Kent and Essex.*

These excepted places, according to the same authority, are as follow:—Those belonging to the Port of Sandwich, Deal, Ramsgate, Margate and Whitstable, as creeks or appurtenant to the member; Dover, Queenborough, as in the same relation to Rochester and Faversham; Milton and Rochester as members themselves of the Port of Sandwich; Malden and Colchester as members of the Port of Ipswich; Leigh, Burnham and West Mersey, as creeks or appurtenant to Malden; East Mersey, Brickley and Wivenhoe, as similarly related to Colchester; and Manningtree and Harwich to Ipswich. Of our harbour, London is the Port, and Gravesend the creek or appurtenance.

The property of the rivers and rivulets that fall into the Thames, with the above-named exceptions, their fish and the soil beneath, within certain boundaries, are vested in the Corporation of London, as mentioned in the former Chapter, page 1, § 3; and the limit of their jurisdiction with respect to breadth,

* '*De Jure Maritimo et Navali*,' 1677, p. 329.—See the above wood-cut

is the highest water-mark on every side, and over all breaches and overflowed grounds, and upon the conjoining creeks, as far as the water ebbs and flows. In the River Lea, near Blackwall, the extent is about a mile above the bridge at Temple Mills, and in the River Medway to the stone near Cockham Wood. Mr. Jones, the Solicitor to the Admiralty, in his evidence before the Select Committee of the House of Commons, August 1, 1836, affirms, that "the Crown, by its prerogative, has the property in the sea, and in all navigable rivers which have the flux and reflux of the sea, and in every arm of the sea or navigable river, so high as the sea flows; and this property extends as well to the soil as the water." By the *magna custuma et antiqua*,* the King is the guardian of the ports within the realm, *et custos totius regni*, and to that extent the Crown has delegated this power to the Corporation of London, we have abundantly shown in the first Chapter, and subsequent parts of this work.

§ 2. The divisions of the Port of London, as defined by the by-laws and customs of the harbour service, are, the *Upper Pool*, the *Lower Pool*, *Limehouse Reach*, *Greenwich Reach*, *Blackwall Reach* and *Bugsby's Reach*.

The Upper Pool is that portion of the River which extends from London Bridge to Wapping Dock Stairs, and is, as mentioned in the first chapter, page 10, § 8, under the management and direction of the Upper Station Harbour-master. The breadth of the River at low-water mark in the Upper Pool is, at the Custom House Stairs, 630 feet; at the Tower Stairs, 593 feet; at Irongate Stairs, 700 feet; in which subdivision of the Pool, the Harbour-masters are, by the 17th section of the by-laws, to provide the greatest possible accommodation for shipping in the coasting and other trades, and to maintain as far as is practicable a navigable passage of not less than 200 feet, for ships, vessels, steam-boats and craft passing up and down that part of the River. At the Alderman's Stairs, the water-way at low water is 690 feet; at the Hermitage Stairs, 645 feet; at Union Stairs, 655 feet; and at the Wapping entrance of the London Docks, 677 feet. In this, and in every part of the Pool and Port, by the 16th section of the by-laws, that is, between Irongate Stairs and Bugsby's Hole, they are to keep a similar navigable passage of not less than 300 feet.

The course of the River from London Bridge to the London Docks, is N.W. by N. and S.E. by S.; from the London Docks to Wapping Dock Stairs, from W. to N.W. by W. and East to S.E. by E.

The Lower Pool extends from Wapping Dock Stairs to Limehouse Stairs, and is under the direction and management of the Central Station Harbour-master. The water-way at low water, off Bell Wharf Stairs, is 845 feet; off Stone Stairs, 730 feet; off Ratcliffe Cross Stairs, 680 feet; off the Regent's Canal entrance, 656 feet; off Duke Shore Causeway, 566 feet; and off Limehouse Stairs, 688 feet. The navigable way in this portion of the River is also to be 300 feet.

The course of the River in the Lower Pool lies from W.N.W. ½ N. to W. by S.; and E.S.E. ½ S. to E. by N. The flood and ebb tides set strong along the north shore, particularly between the Regent's Canal and Shadwell Dock, when it crosses the River between that place and Church Hole. In the lower part of this reach the ebb tide runs strong. *(See the larger Chart.)*

In this part of the River all the collier vessels are moored in tiers, according to the regulations pointed out in the by-laws, as mentioned in Chapter I., page 2, and as shown on the larger Chart.

The depth of water at low water, ascertained by soundings taken by the Harbour-masters, and corroborated by others taken by the Port of London Surveyor, in the Pool, is from ten to sixteen feet in the navigable channel, and from three to twenty feet in the inside of the tiers, the channel left for barges and boats.

Limehouse Reach is that portion of the River which extends from the upper entrance of the City Canal, or the West India Southern Dock, to the Red House at Deptford, and averages in width

* '*De Jure Maritimi et Navali*,' p. 295.

of water-way at low water nearly 900 feet. The course of the River in this reach lies about N.N.E. and S.S.W. The flood and ebb tides set directly up and down this reach, but stronger on the east than on the west. The water is also somewhat deeper in this reach, and the channel more regular on the east side than in the preceding.

Limehouse Hole is that portion of the River which extends from the Regent's Canal to the upper entrance of the City Canal; its water-way at low water at Limehouse Hole Stairs is 688 feet; at the West India Dock entrance, 740 feet; at the Limehouse entrance of the City Canal, 854 feet; and about the same average depth as the preceding. The River in this part runs from N. ½ W. to N.N.W. ½ W., and S. ½ E. to S.S.E. ½ E. The flood and ebb tides set strong both up and down the east and north shore, leaving an eddy or slack tide on the opposite shore. The shore from the Regent's Canal to Limehouse Hole Stairs is for the most part flat, and composed of hard gravel; that towards the canal is more steep. From the Queen's Sufferance Wharf to Cuckold's Point, the shore is composed of a sandy flat, which runs far out from the point. *(See Chart.)* Towards the Horseferry it becomes somewhat steeper, and is chiefly sand. Close to the shore all the way it is shallow, but suddenly deepens to sixteen and eighteen feet, forming a good channel. *(See Table of Soundings, and the Chart.)* The flood and ebb tides set directly up and down the River, but stronger on the south side than on the north, and stronger still in the middle of the channel. Abreast of the Queen's Anchor Wharf, and nearly in-shore, is a shoal which is nearly dry at low water; outside of it, and near to the sheer hulk, are from sixteen to seventeen feet water; at the Red House, fifteen feet; and at Limehouse Hole, on an average, sixteen feet.

Greenwich Reach is that circuitous part of the River, which extends from the Red House, or Victualling Office at Deptford, to the beginning of Blackwall Reach, near Millington's Anchor Wharf; and runs in a circular direction from S.S.E. to E. by N. The circuitous navigation round the Isle of Dogs, through Greenwich Reach, was formerly to be avoided by passing through the City Canal, from Limehouse to Blackwall; but this Canal having been sold by the Port of London Committee in 1829, to the West India Dock Company, and having been enlarged at the lower end, and converted into an additional dock, called the South Dock, vessels must now go round the Isle of Dogs as formerly. At Deptford Creek a long flat shoal, numbered 4 in the larger Chart, begins and runs down almost to the western end of Greenwich Town, nearly to Garden Stairs. It is nearly dry at low water, but immediately outside of it there are from thirteen to fourteen feet water. On the north shore, off Millington's Anchor Wharf, and close in-shore, is another shoal, numbered 5 in the larger Chart, outside of which is good anchorage in fifteen, sixteen and nineteen feet water.

Blackwall Reach extends from the lower end of Greenwich Reach to Lea Ness, or Blackwall Point, the beginning of Bugsby's Reach, and lies N. by E. ½ E. and S. by W. ½ W. Vessels may anchor any where between the Folly House and the upper end of Blackwall, on the western side, in from twelve to sixteen feet water; and on the eastern side, from sixteen to eighteen feet water. The tide, especially the ebb, sets strong in this part, across the entrances of the Canal and the West India Docks.

Bugsby's Reach, the last portion of the Port of London which is under the government of the Harbour-masters and the by-laws, extends from Lea Ness, the lower extremity of Blackwall Reach, and lies about S. by E. ½ E. and N. by W. ½ W. From the shore, all the way between Bow Creek and Hook Ness, a shelf extends nearly one-third over the River, on which are only five or six feet at low water.

§ 3. Soundings of the River Thames in the Port of London, between London Bridge and Bugsby's Hole, from low-water mark on one side of the River to low-water mark on the other side, taken and ascertained by the Harbour-masters between the months of September, 1829, at the time when the recently rescinded by-laws were established, and the last survey completed in October, 1834, by the Surveyor of the Port of London, conjointly with the Harbour-masters; when a general proof of the former soundings was ascertained, and reported to the Port of London Improvement Committee in 1830-1831, and in February, 1836. *(See the larger Chart.)*

SOUNDINGS ACROSS THE RIVER AT LOW-WATER MARK IN FEET.

FROM TRINITY STANDARD. TO

Cotton's Wharf-14-15-15-15-14-14-14-13-15 14-14-14-15-12-12-Billingsgate

Battle Bridge-10-11-11-10-11-11-11-11-11-12-12-9-7-Custom House Lower Stairs

Ditto [Waterway at low-water mark 630 feet] Ditto

Symond's Wharf-12-12-12-13-14-15-15-15-15-16-15-14-12-12-11-Brewer's Quay

Pickle Herring-11-11-12-12-12-12-12-12-12-13-13-13-10-Above King's Stairs, Tower

Ditto [......... Width as above, 593 feet......] Ditto

Davis's Lower Wharf-9-10-10-10-11-11-11-12-12-12-13-14-14-13-12-12-11-Irongate Stairs

Horselydown Old Stairs [................ Width as above, 700 feet ....] Ditto

Butler's Wharf-9-9-10-10-10-11-9-9-10-12-13-14-15-18-17-17-14-Watson's Wharf

Horselydown New Stairs-9-9-9-10-11-12-13-14-14-12-10-8-9-9-10-Alderman's Stairs

George's Stairs [......... Width as above, 690 feet ...] Ditto

Mill Stairs-8-10-11-13-14-14-14-14-12-11-10-9-9-Hermitage Dock Stairs

Ditto [......... Width as above, 645 feet] Ditto

East Lane-11-13-15-13-15-15-16-16-15-14-14-11-12-10-8-9-9-Union Stairs

Ditto Stairs [................... Width as above, 655 feet.........]

Fountain Stairs-7-7-8-9-11-12-14-19 19-19-19-20-20-20-20-21-19-14-12-Wapping Old Stairs

Ditto Dock [............... Width as above, 677 feet ....] Ditto Entrance of London Dock

Rotherhithe Stairs-10-10-11-12-14-15-15-16-16-15-16-16 15-Baltic Wharf

Princes Stairs-12-13-16-17-17-16-15-15-15-15-14-14-14-14-13-King Henry's Stairs

Church Stairs-14-13-11-10-13-13-13-11-11-13-15-15-15-15-14-Frazer and Hullock's

Tunnel Wharf 9-10-12-14-15-16-17-17-14-14-15-16-17-16-15-14-11-King Edward's Stairs

Hanover Stairs-12-12-12-12-12-18-20-19-18-16-16-16-16-16-16-15-12-12-10-New Crane Stairs

King's Mills-10-11 12-12-13-14-14-15-16-16-16-17-17-17-17-16-14-13-11-10-9-King James's Stairs

Bull Head Dock-7-9-11-11-13-14-15-15-15-15-15-15-15-14-14-14-13-12-10-Shadwell Dock Stairs

Cherry Garden Stairs [................... Width as above, 845 feet ....] Bell Wharf Stairs

King and Queen Dock-5-8-9-11-12-12-12-13-13-14-15-16-15-15-13-12-12-12-11-Bell Wharf

Rotherhithe Upper Tier [................. Width as above, 730 feet ....] Stone Stairs

Globe Stairs-6-11-14-15-15-17-16-16-17-17-17-16-15-15-14-11-11-Ratcliffe Cross Dock

King's Stairs [...................Width as above, 525 feet ....] Direct over

Directly opposite [................... Ditto 680 feet ....] Ratcliffe Cross Stairs

Horse Ferry-10-14-18-20-19-19-19-19 19-18-17-14-13-13-13-11-5-Regent's Canal

Ditto [...................Width as above, 656 feet ....] Ditto

Pageants-4-6-12-13-14-15-16-15-15-14-14-13-12-12-7-Blythe's Wharf

Ditto [............Width as above, 566 feet ......] Duke's Shore Causeway

Jennings's Wharf-9-16-17-21-21-21-20-18-15-14-13-12-12-9-5-Duke's Shore Dock

Shoal, see Chart

Lower part of Jennings's Estate 6-9-18-18-18-18-19-16-16-11-10-8-7-5-5-4-3-Limekiln Dock Yard

Directly opposite [.............. Width as above, 688 feet ..] Limehouse Hole Stairs

Cuckold's Point-6-7-7-9-22-21-20-18-15-12-13-15-15-14-14-14-10-Joad and Curling's Dock

King's Dock Yard-6-12 21-21-21-17-18-18-17-17-17-15-15-13-10-Union Dock Yard

Blackwell's Brewhouse-4-4-9-13-17-19-19-14-14-15-16-17-18-19-18-15-14-12-12-City Canal

Ditto [................ Width as above, 854 feet ....] Ditto

Durand's Wharf-5-6-7-7-9-13-16-15-15-15-15-14-14-14-14-14-13-13-13-Price's Wharfs

Trinity Wharf-6-9-13 14-15-16-14-15-15-13-13-13-12-12-11-11-11-Snoke's Dock

Lower part of Solly's Wharf-9-12-13-13-13-13-12-12-12-12-12-12-12-12-13-14-11-10-10-10-10-8-6-Direct over

The Whiting Shoal, see Chart

Condemned Hole-9-13-14-15-14-15-11-10-9-9-9-11-11-12-12-11-11-11-11-12-10-10-11-10-7-9-9-Direct over

Commercial Dock-4-6-9-9-11-11-12-12-13-15-16-16-17-18-19-20-20-19-15-12-10-10-10-Blacket's Dock

East Country Dock-7-8-9-9-10-11-22-22-22-23-22-22-22-23-14-10-14-8-8-6-6-5-5-Mellish's Wharf

Gordon's Dock Yard, Deptford New Pier-7-11-13-14-15-15-15-16-17-18-16-16-16-15-13-12-10-9-8-8-8-7-6-Mill Wall

Victualling Office-11-12-13-15-15-16-18-20-22-21-21-20-20-18-16-15-12-10-10-8-7-Smock Mill

Below ditto, Causeway-14-14-15-17-19-19-18-17-15-20-20-21-19-19-13-12-11-9-9-7-7-Brown and Lenox's Wharf

Upper slip, King's Yard-13-14-9-12-13-16-16-17-14-21-21-21-23-20-19-18-13-13-9-7-5-Mast House

Lower slip, King's Yard-10-14-18-15-18-20-22-24-25-27-29-23-19-19-17-15-11-8-6-5-3-Below Drunken Dock

Middle Water Gate, Deptford-18-17-18-18-22-21-22-21-20-20-20-20-19-19-19-18-18-18-12-10-11-5-5-Direct over

Barnard's Yard-19-18-20-22-21-24-25-23-22-21-21-22-23-23-22-23-21-21-19-18-9-Ditto

Deptford Creek-11-22-25-26-26-26-27-26-25-27-27-27-27-26-25-25-24-22-21-18-14-10-8-Ditto

Martyr's Yard, Greenwich, near Gas-works-22-21-21-25-25-26-26-26-27-29-28-22-28-26-26-25-22-22-17-14-10-Ditto

The Sun-19-21 23-23-23-23-26-26-26-25-24-22-20-20-19-16-13-Isle of Dog's Causeway

Garden Stairs-21-21-22-22-22-20-19-19-19-18-18-18-16-16-19-18-21-19-17-Direct over

Ship Dock-11-23-23-22-24-24-24-22-23-22-22-24-25-24-22 18-10-10-7-Ditto

Crane Stairs-7 9-11-10-10-11-12-13-13-14-14-14-14-15-16-17-16-16-15-15-14-13-10-Ditto

Crown and Sceptre-9-12 17-17-16-15-19-19-19-19-21-22-21 22-22-19-16 12-10-Ditto

Golden Anchor-8-9-10-11-12-13-14-16-18-17-17-18-19-19-19-20-19-20-17-17-15-11 6-Ditto

Lower part of Shad Wharf-4-3-4-6-7-7-15-12-12-12-13-17-15-15-14-14-13-14-14-14-18-16-18-17-13-5-2-1-1-Ditto

Midway between ditto and Rope Ground-4-6-7-7-8-6-7-8-10-12-13-15-16-18-19-16-17-21-18-16-14-13-13-13-8-10-10-Ditto

Rope Ground-4-7-10-11-13-13-12-12-13-12-13-16-21-17-14-12-13-14-17-17-15-14-12-11-10-8-5-Ditto

Four equal divisions between the Rope Ground and directly opposite to the Folly House .. . . {

-7-10-17-15-19-19-18-17-18-17-17-18-17-17-17-17-17-17-16-13-18-20-21-19-15-12-10-7 5-

-10-11-13-13-15-15-15-15-14-14-14-13-13-11-12-15-16-13-14-15-15-15-14-12-11-8-6-4-3-

-17-16-18-17-17-17-16-17-18-18-17-17-15-15-15-15-15-13-13-12-12-12-12-11-10-10-9-8-4-

-5-10-16-15-16-16-18-18-18-17-18-19-18-18-19-18-18-18-17-16-15-15-14-14-12-12-12-11-11-11-11-10-9-8-7-

} The Folly House

Direct over-9-15-15-15-14-16-18-18-19-19-19-19-19-19-19-19-20-20-17-21-17-17-16-10-9-8-7 Pitcher's Dock

Ditto-11-12-15-16-18-19-19-20-22-21-21-21-18-20-20-20-20-16-16-23-24-12-11-9-7-4-2-5-10-The Gun Tavern

Upper Mooring Post of West India Docks } -8-9-12-13-13-18-19-20-22-22-19-19-19-20-19-22-23-21-20-19-18-15-15-15-15-14-14-14-14-14-13-15-5- { Upper Pier of West India Docks

Third ditto-11-14-18-20-22-24-24-25-25-25-24-24-25-24-24-23-25-27-28-29-24-23-21-20-21-22-22-22-11-Blackwall Stairs

Below the fourth ditto-5-11-16-17-18-20-25-26-26-23-24-26 25-25-25-25-23-22-22-23-23-22-22-22-22-20-18-Middle Dock of Wigram's Yard

Fifth ditto-5-10-13-18-25-25-25-23-25-26-26-28-29-29-29-27-28-28-28-28-28-25-24-21-19-13-5-Lower part of Ditto

First Mooring Post of the East India Docks-2-4-9-14-18-21-21-26-26-26-26-26-26-26-24-18-19-20-26-30-24-25-25-25-7-East India Dock, Lower part of Anchor Wharf

Between 2nd and 3rd ditto-9-19-18-20-21-22-22-19-19-20-20-20-19-19-18-20-21-22-24-26-26-29-34-32-26-25-24-24-18-Causeway of the East India Docks

At the Lower ditto-6-6-9-12-13-15-16-17-17-16-16-15-16-17-16-15-15-15-15-15-16-17-19-19-19-19-16-16-14-14-15-15-15-12-5-Orchard House Causeway

Directly opposite-4-5-11-12-14-15-16-16-16-18-18-20-20-19-19-20-20-18-18-17-15-12-16-17-20-15-14-12-12-13-13-12-10-10-9-9-9-9-9-9-8-7-7-7-6-Bow Creek, in Bugsby's Hole

*

Note.—The asterisks [illegible] centre of the River

	Feet.	Inches.	
The distance on the north side of the River from the Custom House Upper Stairs to the Tower Stairs is	1078	0	
From Tower Stairs to Irongate Stairs	1152	0	
Iron Gate Stairs to Alderman's Stairs	1153	0	
Alderman's Stairs to Hermitage Stairs	642	0	
Hermitage Stairs to Union Stairs	609	0	
Union Stairs to Wapping entrance of the London Docks	712	0	
The Wapping entrance of the London Docks to Bell Wharf Stairs	1010	0	
Bell Wharf Stairs to Stone Stairs	688	0	
Stone Stairs to Ratcliffe Cross Stairs	564	0	
Ratcliffe Cross Stairs to Duke's Shore Causeway	1980	0	
Duke's Shore Causeway to Limehouse Hole Stairs	856	0	
Limehouse Hole Stairs to the West India Dock entrance	675	0	
The West India Dock entrance to second tier below the City Canal	1010	0	
Total length of the north shore from the Custom House Upper Stairs to the second tier of ships below the City Canal	12129	0	or nearly 2½ miles

	Feet.	Inches.	
The distance on the north side of the River, from Battle Bridge to Pickle Herring Stairs	693	0	
From Pickle Herring Stairs to Horselydown Old Stairs	1056	0	
Horselydown Old Stairs to George's Stairs	675	0	
George's Stairs to Horselydown New Stairs	270	0	
Horselydown New Stairs to Mill Stairs	520	0	
Mill Stairs to East Lane Stairs	962	0	
East Lane Stairs to Fountain Stairs	980	0	
Fountain Stairs to Rotherhithe Stairs	929	0	
Rotherhithe Stairs to Elephant Stairs	792	0	
Elephant Stairs to Church Stairs	544	0	
Church Stairs to Hanover Hole Stairs.	780	0	
Hanover Hole Stairs to the Surrey Canal	1015	0	
Total length of the Surrey shore from Battle Bridge to the Surrey Canal	9216	0	or rather less than 1¾ miles.

§ 4. The principal shoals in the Port of London, according to the survey taken by the Port Surveyor, conjointly with the Harbour-masters, and reported by them to the Port of London Improvement Committee, are shown in the larger Chart; these, although drawn to a very small scale, are accurately reduced by the Surveyor from his large Charts in the Town-clerk's office, with all the soundings thereon; copies of which have been made by him for the Select Committee of the House of Commons, and for the Corporation of the Trinity House. They consisted of, 1st, A chart of the shoals in the upper part of Woolwich Reach; 2nd, Ditto of the shoals in Bugsby's Hole; 3rd, Ditto of the Gun Shoal in Blackwall Reach; 4th, Ditto of the shoals in the lower part of Greenwich Reach, and in the upper part of Blackwall Reach; 5th, Ditto of a shoal off Greenwich; 6th, Ditto of the Whiting Shoal, in Limehouse Reach; 7th, Ditto of the shoal at Limehouse Hole.

During the year 1835, plans of the shoals above and below London Bridge have been transmitted to the Port of London Improvement Committee, by their order, and also a plan of the soundings of the River opposite to Her Majesty's Victualling Office, at Deptford. There are also many casual projections and inequalities in the bed of the River, which have arisen more particularly from sluices, sluice-gates, sewers, cleansing docks, moorings and sets of the tide, which ought to be removed at the expense of the Tonnage Duty Fund, for the interest of the shipowners, who contribute to it.

DESCRIPTION OF THE SAID SHOALS,

From the Surveyor's Charts and Harbour-masters' Report, March 1836.—See Chart.

No. 1.—*The Limekiln Shoal,* numbered 2 in the Chart, No. 1 being a small shoal off Alderman's Stairs.

	Feet.	Inches
Runs out from east to west	460	0
From low water mark west side, to the outer edge	235	0

No. 2.—*The Whiting Shoal*, off the Condemned Hole, Limehouse Reach, numbered 3 in the Chart.

	Feet.	Inches.
Off the Acorn Dock-yard, from low-water mark to the inner edge	170	0
Width across the shoal	126	0
Average width of the channel between the shoal and the Isle of Dogs	554	0
Width across the River at low water	850	0
Length of the shoal from north to south	722	0

No. 3.—*Shoal off Millington's Wharf*, Greenwich, numbered 5 in the Chart.

From low-water mark to its outer edge	442	0
On the point from low-water mark to its outer edge	200	0
Navigable channel	237	0
Width across the River at low-water	879	0

This shoal extends from Millington's Wharf, narrowing downwards towards the Rope-ground, at East Greenwich.

No. 4.—The shoal called *the Middle Ground*, Blackwall Reach, numbered 7 in the Chart.

Below the upper sluice on the west side from low-water mark to inner edge	310	0
Width	114	0
Width across the River at low water	890	0

No. 5.—*The Gun Shoal*, in Blackwall Reach, numbered 8 in the Chart.

From low water to its inner edge	167	0
Across the shoal	100	0
Length of the shoal	473	0
Width across the River at low water	1000	0

No. 6.—*Bow Creek Shoal*, in Bugsby's Reach, numbered 9 in the Chart.

Runs out	355	0
And extends to the first sluice in Bugsby's Hole, on the north side	807	0
Width across the River at low water	1162	0

No. 7.—*Brock's Bay Shoal*, in Bugsby's Reach, numbered 10 in the Chart.

Length	1020	0
Its greatest width about the middle, measured from low-water mark to its outer edge	340	0

No. 8.—*A shoal on the north side, opposite Bugsby's Hole Causeway*, which with the following are below the Harbour-masters' jurisdiction, but were surveyed and laid down, by order of the Port of London Improvement Committee, in 1835 and 1836.

	Feet.	Inches.
Runs out from low-water mark southward	530	0

No. 9.—*Cooper's Shelf*, off the Anchor and Hope Public-house, in Woolwich Reach.

Runs outwards	651	0
Width	304	0

No. 10.—*Charlton Upper Shelf*, in Woolwich Reach, off the Sluice.

Upper end from low-water mark	120	0
Lower end ditto	337	0
Length	1122	0

No. 11.—*Charlton Lower Shelf*, in Woolwich Reach.

Off the 3½ mile-post, from low-water mark to the outer edge	680	0
Width	1302	0

§ 5. On the 26th of May, 1834, a communication was made by the Right Honourable the Lords of the Committee of Privy-Council for Trade to the Trinity Corporation, in consequence of their refusing to remove certain shoals and banks in the River, which, by reason of their monopoly, it is said, the Corporation of London may not do.* The Trinity House was again and more forcibly urged by their Lordships to consider of the means by which the shoals which impede the navigation of the River may be removed, who stated also, that the complainants in this matter consider that the Trinity Corporation is bound to remove the obstructing matter, although the substance of it might not be suitable for ballast, because, say their Lordships, the removal of such obstructions constitutes the benefit to the public contemplated in the grant of their charter; and they further requested to be informed of the ground on which the Elder Brethren consider they are not obliged to perform the duty, which, it is asserted by those parties, falls upon that Corporation. Mr. Herbert, the Secretary to that Corporation, replied, that upon the renewed consideration of this subject, and in special reference to the point on which their Lordships desire to be informed, the Elder Brethren are of opinion, that the responsibility which is now attempted to be thrown upon them does not attach to that Corporation.

Before discussing the reasons of the Elder Brethren of this respectable Corporation for non-compliance with this duty, a few words are necessary as to their mode of exercising this privilege.

The complainants, who state that the Trinity House do not remove all obstructing matter to the navigation of the Port of London, for beyond its limits their monopoly does not extend, say, in their Memorial, that the matter which they remove is not always that which is so obstructive, but mostly that which is most profitable to themselves, and by which their ballast-heavers can gain most money. Also, that they are so jealous of any other person removing any obstructive matter to the navigation of the Port of London in the River Thames, that they will not suffer any other person or corporation to remove any matter from the bed of the River Thames, below London Bridge; not even the Corporation of London, for the depositing of the necessary mooring-stones beneath its bed. This latter fact the author of this work can vouch, for it has been his duty for some years to examine and pass the Trinity House bills of charges for excavating proper holes for such mooring-stones, after having been certified by the Superintendent of the Port of London mooring-chains. Also, that when they have been required to move shoals and to make better water over them, they have taken only as much as is profitable, then abandoned the work, and prevented any other person from continuing it.

The complainants also state, that as all the expenses of the harbour service of the Port of London is defrayed out of the tonnage duty laid upon ships frequenting the Port of London, and that as very large balances have been annually paid therefrom to the general consolidated fund; that before such balances had been paid, the Port of London Improvement Committee, who have the entire management of the harbour service, ought to, and perhaps would, if the Elder Brethren had permitted them, have removed such obstructions to the navigation of the Port that the Trinity House left untouched, and have paid the expense of such removal out of the said tonnage duty. They also complain, that the whole of such tonnage duty ought to be expended in improving the Port of London, except some small reserved sum for unexpected and unforeseen outlays, so as to benefit the shipping interest which pays it, by making the Harbour and Port of London the most perfect in the world; and if the tonnage duty be more than is wanted for such purpose, it ought to be reduced so as to render the Port of London also the most easy in its port-dues, which are already less than in any other port in Europe.

The Elder Brethren, in their before-mentioned reply to the Board of Trade, say, that by the grant of the 36th year of Her Majesty Queen Elizabeth, it appears to them, that the lastage and ballastage of all and all manner of ships and other vessels whatsoever, coming and being upon the River of Thames &c. &c., were surrendered by the then Lord High Admiral of England unto Her Majesty, with a request that the same might be granted and confirmed to their Corporation, and that Her Majesty was graciously pleased to grant and confirm the same accordingly, in the manner and for the sole purpose before mentioned.

* See ante p. [illegible] § [illegible]

The Elder Brethren also quote the 17th Charles II., which, upon a surrender of a previous grant of the 15th of that reign, recites, that " Whereas many decayed seamen, their wives, widows and orphans, have from time to time received good relief by the said Master, Wardens and Assistants of the said Trinity House of Deptford-Strond, out of the lastage and ballastage raised and taken forth of our said River of Thames, for the lastage and ballastage of ships and other vessels." The same is thereby re-granted to the said Corporation, and His Majesty is pleased to give unto them " the gravel, sand and soil of the said River of Thames, and every part and parcel thereof, for the ballasting of ships and other vessels."

Let us now examine a little into this matter before proceeding with their reply.

The Trinity Corporation was first founded in the year 1515, by Sir Thomas Spert, Comptroller of the Navy to King Henry VIII., who is mentioned in the statute, 27 Hen. VIII. c. 18, for the preservation of the River Thames, as " having the office and ordering of and for ballasting of ships."

This Corporation received its first charter from that King in the 4th year of his reign, which confirmed to them, not only the ancient privileges of the Mariners of England, an old incorporated body, but also its several valuable possessions at Deptford. Among the principal objects of this foundation, was the increase and encouragement of navigation. Its power over beacons, buoys, light-houses, pilots &c. is purposely omitted in this work as not appertaining to the subject.

Besides the statute 36 Eliz. quoted by the Corporation, their powers are acknowledged by those of the 8 Eliz. c. 13.; a charter of James II. in 1685, which incorporated them by the somewhat glowing title of " *The Master, Wardens and Assistants of the Most Glorious and Undivided Trinity, of St. Clement, in the Parish of Deptford-Strond, in the County of Kent;*" the 5 Geo. II. c. 20, 6 Geo. II. c. 29, the 10 Geo. II. c. 31, and the 32 Geo. II. c. 16.

The Court of this Corporation consists of thirty-one Elder Brothers; which are divided into a Master, four Wardens, eight Assistants, and eighteen Elder Brethren. Of these, eleven are considered noble, or in the honorary class of the Brotherhood, and twenty who are balloted for, after proposition and approbation, by the Elder Brethren from the Younger Brethren, whose number is indefinite, but who must have been commanders of vessels in the merchant service on foreign voyages for at least four years, and have other qualifications as resolved at a General Court, held on the 5th January, 1815, and are consequently self-elected. The eleven Honorary Brothers consist of Admirals in the Royal Navy, Ministers of State and other persons of distinction. Other officers of the Royal Navy are ineligible, because, from their rank, they may be hereafter eligible as Honorary Elder Brethren, except when they have entirely left the Royal Navy and qualified in the mercantile navy according to the regulations of the Corporation.

Of this Court there are several Committees, and among them one for the supervision of the ballastage of the River Thames, consisting of two Elder Brethren, one of whom goes out annually. They have the charge of the River Thames from London Bridge downwards, for ballast purposes, as far as they like to go, but they seldom go below Erith.

The Elder Brethren in the hereinbefore-mentioned reply to the Board of Trade, forbear to occupy their Lordships' time with the recital of many other passages to the same effect as to ballastage, and the grant of the gravel, sand &c. of the River Thames; which grant is expressly for the " *better advancement of the said work of cleansing the said River, and the more speedy and effectual performance, perfecting and accomplishing of the same, so much tending to the benefit of the commonwealth.*" So do they also forbear to state the authority by which they prevent other persons from *benefiting the commonwealth* by cleansing the River and improving the navigation of the Port of London. But they do not forbear to observe in the same document, " that while they have been at all times desirous and ready to render the execution of the office they hold, under the royal grant before recited, available to the removal of annoyances and obstructions to the navigation of the River Thames,

so far only as the materials of which they have consisted could be rendered available to the ballasting of ships, they are not in any degree desirous of avoiding any responsibility which can be justly considered to attach to them, for the removal of obstructions of *a different description,* provided it shall be the pleasure of Her Majesty's Government to place at the disposal of their Corporation sufficient funds for that purpose, independent of *the profits* of the lastage and ballastage, as unquestionably appears by the terms of the royal grant to have been originally intended."

Whatever it may appear to the Elder Brethren of this highly respectable and well-conducted Corporation, as to *the profits,* it may appear to less interested persons, that these *profits* (alone) are not for *the benefit of the commonwealth,* as promulgated in the aforesaid royal grant.

By the Report of the Select Committee on Lighthouses, *ordered by* the House of Commons to be printed, August 1834, no return is given of these *profits,* although No. 5 of the Appendix to that Report is called "A return of the *whole* receipt and revenue of the CORPORATION OF TRINITY HOUSE OF DEPTFORD-STROND, distinguishing the particular services from which the same are derived for the year 1832," and professes to give every source from which such revenue is derived. Yet, in the Report of the Select Committee on Foreign Trade, *ordered by* the House of Commons *to be printed* in 1822, they declare the net profits of the ballastage, in 1820, to be £1962,* a trifle short of two thousand pounds a year; and admit, by the evidence of Aaron Chapman, Esq. M.P., an Elder Brother of twenty-four years standing, before the Select Committee on Lighthouses, on the 9th of May, 1834, that since the institution of the Trinity Corporation, 400 million of tons of ballast (all profit, according to their own showing) had been raised in the River Thames; admitting at the same time, that they have the means of keeping the River Thames clear, in consequence of the great coasting trade, and the consequent great demand for ballast.

Whence, therefore, may the complainants to the Lords of the Committee of Her Majesty's Privy-Council for Trade boldly ask, are the reasons why the Elder Brethren of the Trinity House refuse to remove "obstructions of a different description," (from profitable) "unless Her Majesty's Government will place at their disposal sufficient funds for that purpose, and at the same time prevent the Port of London Improvement Committee, who have the surplus funds of the tonnage duty, paid by the shipping owners for the shipping interest, in their hands, from effectually cleansing the said River, so much tending to the benefit of the commonwealth?"

To pursue this argument a little farther. In the case *Weston* v. *Trinity House,* the Lord Chancellor, in 1774, gave judgment as to the powers of this Corporation in passing the decree, and said, "that the Crown, as every Prince has a maritime right, has a right to erect beacons, which right falls to the right of the Lord High Admiral of every nation, and is a great trust." * * * *

"From Elizabeth's time the Corporation has had a right to fix beacons; but it is essential to the public that the Corporation should be the supervisors, and only the supervisors, for *it would be dangerous to have them interested.*" * * * *

"But what are the powers given them" (the Trinity House) "by this charter? These powers are of a maritime kind, and, in consideration of these services, to receive certain tolls and duties, which after they have applied to reimburse the necessary charges, and the payment of certain salaries and stipends, (which they allot their servants, and those who hold offices among themselves), the remainder is to be disposed of by them to such and such particular charities." * * * *

"But whatever powers the Corporation have, with respect to the Eddystone" (the case in question),

	£	s.	d
* In 1831, according to M'Culloch's 'Dictionary of Commerce,' the Receipts for ballastage was	30,239	17	9
And the cost of procuring the same	23,741	15	11
Leaving a net, for that year, profit of	6,498	1	10

"they are derived wholly and solely to them from the Acts of Parliament (4 and 5 Anne, c. 20, and 8 Anne, c. 17) for rebuilding that lighthouse, with which that charter has no connexion."

So, it may appear to these complainants, that from Elizabeth's time to those of the statutes of 6 Geo. II. c. 29, which recites and confirms their various grants from the Crown to the lastage and ballastage on the River Thames, and the sole right of supplying all ships and vessels with ballast that sail between London Bridge and the main sea, and 39 Geo. III. c. 69, called the Wet-dock Act, which enlarges the powers of this Corporation in the Port of London; that the Crown as Prince, possesses the right of lastage and ballastage in the River Thames, which right falls to the Lord High Admiral; and that the Crown delegated that right to the Elder Brethren. But, as the Lord Chancellor says, they "should be the supervisors, and only the supervisors, for it would be dangerous to have them *interested*." The results prove the fact, for being interested to the amount of between six and seven thousand pounds* a year, they not only apply this to their own private purposes, instead of improving the Port of London, by removing all the shoals and obstructions, whether fit for ballast or not, but also prevent the Port Committee, who have funds paid by the shipowners as tonnage duty, from doing it. The balance of this and other funds collected from the shipping interest, is most laudably expended on pensions to poor disabled seamen of the merchant service, and on the maintenance of their widows, orphans &c.; but the public interest of such a port as that of London, should not be put in competition with objects the maintenance of which should be provided for in other more direct ways.

Under the present system of ballastage by the Trinity House Corporation, the regulations are as follows—namely, a sum of £10 is to be paid for every ton of ballast taken from the channel of the River without due authority from the said Corporation. Ships may receive on board land ballast from the quarries, pits &c. east of Woolwich, provided the quantity taken in a year do not exceed the number of tons notified to the Trinity Corporation. Land ballast must be entered at 1*d.* per ton, paid on entering. No ballast is to be put on board before entry at the ballast-office, under a penalty of £5 a ton. The Trinity Corporation is authorized by the 3 Geo. IV. c. 3, to charge the following rates for all ballast demanded and entered at the ballast-office, viz.:—

For every ton (20 cwt.) of ballast, not being washed ballast, carried to any ship or vessel employed in the coal trade, the sum of 1*s.*

For every such ton carried to any other British ship or vessel, the sum of 1*s.* 3*d.*

For every such ton carried to any foreign ship or vessel, the sum of 1*s.* 7*d.*

For every ton of washed ballast carried to any ship or vessel employed in the coal trade, the sum of 2*s.*

For every ton of washed ballast carried to any other British ship or vessel, the sum of 2*s.* 6*d.*

For every ton of washed ballast carried to any foreign ship or vessel, the sum of 3*s.* 2*d.*

And for every ton of ballast delivered in, or unladen from the inward West India Dock, the further sum of 10*d.*; and for every ton of ballast delivered in or unladen from the outward West India Dock, the further sum of 4*d.*; and for every ton of ballast delivered in or unladen from the London Docks, the further sum of 4*d.*; and for every ton of ballast delivered in or unladen from the inward East India Dock, the further sum of 10*d.*; and for every ton of ballast delivered in or unladen from the outward East India Dock, the further sum of 4*d.*; and for every ton of ballast delivered in or unladen from the Commercial Dock, the further sum of 4*d.*; and for every ton of ballast delivered in or unladen from the East Country Dock, the further sum of 4*d.*; and for every ton of ballast delivered in or unladen from the

* See ante page 24

City Canal, the further sum of 4*d.*; and for every ton of ballast delivered in or unladen from the Surrey Canal, the further sum of 4*d.*; and for every ton of ballast delivered in or unladen from the Regent's Canal, the further sum of 4*d.*

Which further rates or prices shall be payable and paid over and above the respective rates first mentioned.

In 1832, the gross receipt of sums paid on account of ballast to the ballast-office on the Thames, was £25,220. 19*s.* 4*d.* The expenses amounted, during the same year, to about £23,000.

The ballast of all ships or vessels coming into the Thames is to be unladen into a lighter, at the charge of 6*d.* a ton. If any ballast be thrown or unladen from any ship or vessel into the Thames, the captain, master &c. shall, for every such offence, forfeit £20. No ballast is to be received on board otherwise than from a lighter. By the statute 54 Geo. III. c. 149. it is enacted, that no person shall, under a penalty of £10 over and above all expenses, discharge any ballast, rubbish &c. in any of the ports, harbours, roadsteads, navigable rivers &c. of the United Kingdom; nor take ballast from any place prohibited by the Lords of the Admiralty.

The masters of all ships clearing out in ballast, are required to answer any questions that may be put to them by the collectors or comptrollers, touching the departure and destination of such ships; 3rd and 4th William IV. c. 52.

If a foreign ship clear out in ballast, the master may take with him British manufactured goods to the amount of £20; the mate, the value of £10; and £5 worth for each of the crew.

§ 6. The commerce of the Port of London so far exceeds that of any other port in the world, that its title to being the emporium of the world is indisputable. In the reign of Elizabeth, its commerce was not in a very flourishing condition; for in 1561, there was no Englishman in London following the exclusive occupation of an importer or exporter; and in a letter written to Sir William Cecil, when Secretary of State, by the principal traders in London, complaint is made, that, although no city in Europe had equal convenience for shipping, none was so slenderly supplied. That a great want of English ships was experienced to lade goods for Spain, and that none were to be had, and that even thirty-seven hoys then employed in bringing timber from Rye, had not an English seaman among them.*

Yet in far more ancient days, London stood high in a commercial point of view, such as became the metropolis of a sea-girt isle; Tacitus† calling it celebrated for its many merchants, and the abundance of its provisions; and Strabo bearing testimony that Britain exported corn, cattle, gold, silver, iron, horses &c., and imported salt, earthenware, works in brass, ivory, amber &c.;‡ and Herodian calls it a great and a wealthy city, in the second century. In the time of Alfred, our ancient historians relate that the merchants of London traded to the East Indies, and brought from them precious stones, which still remain in the most ancient crown, wherewith Alfred and his successors were crowned; and so highly was naval commerce estimated in those early periods of our history, that in the year 925, Athelstan enacted a law, that every merchant, who made three voyages to the Mediterranean Sea, on his own account, should be raised to honour, and enjoy the privileges of a gentleman.

Ethelred, about the year 1000 of the Christian era, made laws at Wantage, for the regulation of the customs on ships and merchandise, to be paid at Billingsgate, the particulars of which are detailed in Howell's 'History of the World.'§ The merchants of the Steel-yard, under the name of the emperor's men, are specially favoured, which proves the antiquity of that body of merchants. In Stephen's time, merchants of all nations, says Fitzstephen, an historian of his reign, had their distinct wharfs and quays; the Germans and Dutch at the Steel-yard, and the French for their wines at the Vintry, so named from that circumstance.

* Stowe.
† "Londinium, copia negociarum et commeatu maxime celeberrimum."
‡ Strabo, lib. iv.
§ Vol. III. part iii. c. 2.

In the latter part of the reign of Edward III., as recorded in the Fœdera,* disputes arose between the King and the Citizens, as to the undue encouragement which, in their opinion, was given by the King to the foreign merchants; which produced a letter from the King to the Mayor and Sheriffs, in 1369, wherein he tells them, "that he is informed the people of that City" (London) "were daily offering injuries and insults to the merchants and others of Flanders and Lombardy living in and resorting to London, although the said foreigners came thither under his protection, and the faith of his proclamation for the public good, and the advantage of the kingdom. As, therefore, they have an undoubted claim to be protected from all manner of wrongs, he commands the said Mayor and Sheriffs to make proclamation in their City and suburbs, that none, of what degree soever, do presume to offer any sort of injury, either to the persons or goods of the said foreigners, under the severest penalties." The Citizens renewed their applications in a more formal way by petition, complaining that this encouragement was contrary to the great charter; tended "to the great destruction as well of the said City, common damage of the land, as also of the navy." To which the Citizens received the following laconic answer—"Let them particularly show the breach of any liberty, and they shall be answered."

According to the same authority,† Chaucer, the father of English poetry, was appointed, in 1374, to the office of Comptroller of the Customs &c. in the Port of London, on the express condition of writing, "with his own hand, the registers or entries belonging to his said office of Comptroller, and shall constantly act in person in his said office, and not by a deputy or substitute." Previously to this appointment, he had obtained a grant, perhaps as poet-laureate, of one pitcher‡ of wine, to be daily delivered to him by the King's butler, during his life, at the Port of the City of London.

The Foreign Trade of the Port of London appears to have been very early commenced with Africa and Russia; and it is a curious circumstance, says Mr. Colquhoun, in his treatise on the Police of the River Thames, that in those early voyages the great officers of state were generally concerned as commercial speculators. Thus, in 1563, an adventure was undertaken by several merchants to Maderabombo, in Africa, in which were the Earl of Pembroke, Lord Robert Dudley, then Lord High Admiral of England, and Sir William Cecil, Secretary of State. The expedition consisted of four vessels, navigated by 150 seamen; the wares and victuals for the Negroes, with their apparel and habiliments of war, amounted to one thousand one hundred and ninety pounds, and the whole charge of the adventure to three thousand three hundred pounds. The adventurers were the three before-mentioned statesmen, five merchants, and two master mariners. This is one of the earliest joint-stock or sharing companies belonging to the Port of London on record, and is perhaps the foundation of that unrighteous traffic—the slave trade.

It is singular, notwithstanding the comparative paucity of the commercial trade of the Port of London at this period, when Elizabeth ascended the throne of England in 1558, the same extent of legal quays was authorized as in the year 1800.

Various other speculative voyages of a similar nature are recorded to have taken place in the early period of Elizabeth's reign, in which the Queen's ministers were among the adventurers. Yet some spirit of adventure must have existed among the merchants of the Port of London previous to that reign; for the first charter to "The Hamburgh Company," the oldest commercial body in the realm, was granted in 1406, by Henry IV., and renewed by succeeding sovereigns in 1413, 1442, 1493, 1505, 1506, 1517, 1531, 1547, 1553, 1564, 1586, 1605 and 1661.§

This venerable parent of the commercial companies in the Port of London, was originally formed so far back as 1296, and, as is said, by the Guild of Mercers of the City of London, who were the first English merchants that attended to the manufacture of woollen cloths in England. They obtained commercial privileges from John, Duke of Brabant, established a staple at Antwerp, and joined in mercantile union with all the merchants who traded thither. Henry IV. granted them their first charter, as before mentioned, under the name of "The Brotherhood of St. Thomas Beckett, Archbishop of

* Vol. VI. p. 618. † Vol. VII. p. 38. ‡ In the original, *Unum pycher.* § Colquhoun.

Canterbury." This charter was much augmented by Henry VII., and embraced the whole body of English merchants trading from the Port of London, under the title of "The Company of Merchant Adventurers trading to Calais, Holland, Zealand, Brabant and Flanders." Elizabeth enlarged their powers, confirmed their privileges, and incorporated them anew in 1566, under the title of "The Company of Merchant Adventurers of England." They received a second and enlarged charter from the same public-spirited Queen, confirmations thereof from James I. and Charles I., from Parliament in 1643; but for some years past this ancient Corporation, latterly known by the title of the "Hamburgh Company," through the diminution of their privileges, and the laying open their trade in the reign of William III., has fallen into desuetude.

The Russia Company was established in the reign of Edward VI., in consequence of the discovery of a passage to that country by the northern extremity of Norway and Lapland. The premature death of the young King occasioned the charter prepared for his execution to be granted by his sister, Queen Mary, in the 1st and 2nd year of Philip and Mary, and subsequently confirmed by the statute of the 8th Elizabeth, under the title of "The Fellowship of English Merchants for Discovering new Trades." It is to these powers and privileges that we are indebted to this Company for the discovery and settlements of the Cherry Islands, Greenland, Nova Zembla, Newfoundland, Davis's Straits and Hudson's Bay. Their first governor was the celebrated and adventurous mariner, Sebastian Cabot. By this charter no part of the continent, no island, harbour &c., to the north or north-east of the Port of London, under the dominion of the Emperor of Russia, or in the countries of Armenia, Media, Hyrcania, Persia or the Caspian Sea, should be visited by any subjects of England, to exercise any commerce, without the consent of the said Company, on pain of confiscation.

Their charter was further enlarged and confirmed by James I. They obtained permission from the Empress Elizabeth to trade with Persia through her territories; but on one of their agents, Mr. Elton, being ordered by Kouli Khan, of Persia, to build some ships of war in the Caspian Sea, she revoked the permission.

This Company remained entire masters of the trade to Archangel, till the time of Cromwell, when the Dutch, having gained a powerful influence in the Court of Russia, their minister, fearing a people which had beheaded their king, favoured the Dutch to the extent of their power. After the restoration of Charles II., the Russia Company recovered a portion of the Archangel trade, and by the statute 10 and 11 William III. c. 6, received the powers and privileges by which they are guided. The table of duties payable to this Company, at the present day, is detailed in the last edition of M'Culloch's 'Dictionary of Commerce,' under its proper head. Samuel Thornton, Esq., is the Governor, with four Consuls, twenty-six Assistants, a Chaplain at St. Petersburgh, another at Archangel, and Thomas Cope, Esq. Secretary.

The Eastland *or North Sea Company*, was incorporated by charter of Queen Elizabeth, in 1579, the 21st year of her reign, under the title of "The Fellowship of Eastland Merchants," and were to enjoy the whole trade to Norway, Sweden, Denmark, Poland, Prussia and all other parts of the Baltic. This charter was confirmed by Charles I., in 1629, with the addition that their members were to be previously free of the City of London; their privileges were curtailed by Act of Parliament in 1672, and since the declaration in the Bill of Rights of 1689, the Company has little more than a nominal existence. Its meetings are held at the Merchants Seamen's Office, Royal Exchange. George Norman, Esq., Governor, and Thomas Cope, Esq., Secretary.

The Greenland Company, trading to the Greenland Seas for the catching of whales &c., was established by the statute 25 Charles II., and confirmed by that of the 4 and 5 William and Mary, but for the same reasons as the last Company it shared the same fate, and the trade extended to the public at large.

The East India Company. The best historical account of this Company is to be found in M'Culloch's admirable 'Dictionary of Commerce,' under its alphabetical head, and to which the

inquiring reader is referred for more ample detail than we can spare room for. It is indeed a faithful and most interesting history, skilfully abridged from the 'Modern Universal History,' Macpherson's 'Commerce of the European Powers with India,' and other authentic documents.

According to Stowe and other civic historians, when the trade and navigation on the English coasts had been greatly disturbed by the depredation of the Spaniards, and a new route to the East Indies had been discovered by Captain Stevens, Cavendish and other English navigators, an association was formed in London, in 1599, for prosecuting a direct trade from the Port of London to India. The adventurers accordingly applied to Queen Elizabeth for a charter of incorporation, who, on the 31st December, 1680, granted a charter to George, Earl of Cumberland, and to two hundred and fifteen Knights, Aldermen and Merchants, under the denomination of "The Governor and Company of Merchants of London, trading to the East Indies."

Their first Governor was Thomas Smythe, Esq., who with twenty-four Directors were nominated in the charter; their first subscribed capital was £369,891. 5*s.* 0*d.*, in shares of £50 each; their first adventure commenced with five ships, the largest being 600, and the smallest 130 tons burden, the cost of which, says Mr. M'Culloch, amounted, ships and cargoes included, to £69,091. The chief command was intrusted to Captain James Lancaster, who had already been in India; and this their first expedition sailed from Torbay on the 13th February, 1601. The voyage, though necessarily protracted, from the imperfect acquaintance of the navigators with the seas and countries they were about to visit, was uncommonly prosperous. Commodore Lancaster, having entered into advantageous commercial treaties with the Kings of Acheen and Bantam; having disposed of his cargoes, consisting of bullion, iron, tin, broad-cloths, cutlery, glass &c., and having taken on board a valuable cargo of pepper and other Oriental produce, he returned home, capturing in his way, in concert with a Dutch East Indiaman, a richly-laden Portuguese carrack, of 900 tons burden. The expedition arrived in the Downs the 11th of September, 1603.

In 1685, the Company's ships were increased to about forty, including the country traders to the East Indies and China.

The wonderful increase of this great Company, so intimately and solely connected with the Port of London, from this period to that of its dissolution by Act of Parliament, in 1834, when it had become, from a Company of Merchants, a conclave of sovereigns of many rich and powerful kingdoms, will afford to the future historian some of the most astonishing and remarkable series of events that have ever occurred in the history of the world.

Having briefly but correctly given an account of the origin of this great Company, I shall give as correctly, from the pages of Mr. M'Culloch, an account of its close.

"But, besides," says this accurate writer, "being injurious to the private trader, and to the public generally, both in India and in England, this trade was of no advantage to the East India Company. How indeed could it be otherwise? A Company that maintained armies and retailed tea—that carried the sword in one hand and a ledger in the other—was a contradiction; and, had she traded with success, would have been a prodigy. It was impossible for her to pay that attention to details that is indispensable to the carrying on of commerce with advantage. She may have gained something by her monopoly of the tea trade, though even that is very questionable; but it is admitted on all hands, that she has lost heavily by her trade to India. When, therefore, the question as to the renewal of the charter came to be discussed in 1832 and 1833, the Company had no reasonable objection to urge against their being deprived of the privilege of trading. And the Act 3 and 4 Will. 4, c. 85, for continuing the charter till 1854 *has terminated the Company's commercial character.*" Its present principal officers are—Sir James R. Carnac, Bart., *Chairman;* John Loch, Esq., *Deputy-Chairman;* James C. Melvill, Esq., *Secretary.*

Therefore, since the 22nd April, 1834, the day on which the Company's commercial character

ceased, and from which its functions are to be wholly political, its connexion as a public body with the Port of London ceased also, and the India and China trades therefrom are conducted by individuals. Its docks, situated at Blackwall, and its great warehouses on the banks of the Thames, and in other parts of the City of London, have been disposed of by the Company to other companies and individuals, as hereinafter described.

The Turkey or *Levant Company* owes its origin to an association of Barbary Merchants, who were established by charter in the reign of Henry VII., which, falling into decay, was revived in the reign of Queen Elizabeth, who incorporated them soon afterwards by a provisional charter in 1581, for the term of seven years, to Sir Edward Osborn, an Alderman of London, and three other merchants. Sir Edward became its first governor, and the Queen sent a special envoy to negotiate their friendly reception in Turkey, on board the ship Susan of London, carrying thirty-four guns.

Their charter was renewed by the Queen in 1593, which incorporated fifty-three Knights, Aldermen and Merchants of London for twelve years, under the title of "The Governor and Company of Merchants of the Levant," the extent of their privileges to be the Venetian territories, the dominions of the Grand Seignior, by land and sea, and, through his dominions, over land to the East Indies.

On the expiration of that charter, it was renewed by James I., by letters-patent of Charles II., compelling its members to be previously free of the City, and subsequently by statute 26 Geo. II. c. 18, till it was abolished by the statute 6 Geo. IV. c. 23.

During the seventeenth century, and previous to any authentic records being preserved of the *Port of London*, a new source of commerce was opened by the discovery and settlement of various colonies in America. Even as far back as 1584 and 1585, Sir Walter Raleigh sent nine ships to Virginia, and is believed to be the first who introduced tobacco from that colony, although it had been introduced into Portugal, in 1560, by Jean Nicot, the French Ambassador in that country, from whom it received its botanical name *Nicotiana Tabacum*. This article of commerce produced a revenue of customs and excise to the Crown for the year ending January 5, 1800, the sum of

	£	s.	d.	£	s.	d.
For Great Britain	987,110	8	8			
For Ireland	327,916	9	0			
				1,315,026	17	8

and for the year 1832,

	£	s.	d.	£	s.	d.
For Great Britain	2,428,532	0	0			
For Ireland	652,566	0	0			
				3,081,098	0	0
Making an increase in favour of the latter year of no less than*				£1,766,071	2	4

During the same century the sugar colonies had their origin, which, from being totally unproductive, gave employment in 1799, according to Colquhoun, to above 450 ships from the Port of London alone, and yielded

	£	s.	d.
A net revenue that year of	2,321,935	16	5
In 1832, the revenue, according to the Parliamentary Papers, amounted to	3,986,519	0	0
Making an access of revenue for that year of	£1,664,583	3	7

and a similar ratio of increase of ships belonging to the Port of London.

The gross receipts of the duties on sugar for the year ending the 5th January, 1836, was

	£	s.	d.
For Great Britain	4,991,031	0	0
For Ireland	406,601	0	0
Amounting to	£5,397,632	0	0

* Parliamentary Papers, No. 340, Sess. 1829; No. 747, Sess. 1833; and No. 212, Sess 1834.

from which deduct bounties paid on British refined sugar exported

	£	s.	d.	£	s	d
From Great Britain	709,015	0	0			
From Ireland	396	0	0			
re-payments on over-entries, damages &c.						
For Great Britain	19,322	0	0			
For Ireland	1,023	0	0			
				729,756	0	0
Leaves a net produce of the duties on sugar for that year				£4,667,876	0	0

the whole of the curious details of which are carefully and elaborately shown in M'Culloch's 'Dictionary of Commerce,' under the head "Sugar."

The African Company.—The English merchants first sent ships to Africa for commercial purposes about the year 1553, from which time it was carried on by private merchants, till 1558, when Queen Elizabeth, by letters-patent, erected a Company of London merchants, for the more effectual promoting of the African trade, which was confined to gold, elephants' teeth, and Guinea pepper.

This Company was greatly encouraged during the reigns of James I. and Charles I., till the Dutch, having captured several forts on the coast of Africa from the Portuguese, and committed many depredations upon the English, induced the government in the reign of Charles II. to incorporate a larger and more powerful body of merchants, with the King's brother, James, Duke of York, at their head, in 1662, under the title of "*The Company of Royal Adventurers of England to Africa.*" This incorporation was enlarged in 1672, and their trade laid open to the public in 1697. This trade was further regulated by the statute 23 Geo. II. c. 3, and other subsequent statutes, till finally abolished by statute 1 and 2 Geo. IV. c. 28.

The Hudson's Bay Company.—The extensive countries through which this Company trade were among the important discoveries made by Sebastian Cabot, at the joint expense of King Henry VII. and the merchants of the Ports of London and Bristol, of which latter place Cabot was a native. Yet the commercial intercourse between the two countries does not appear to have been fully settled till after Prince Rupert and some London merchants sent out two vessels, in 1669, to inquire into the nature of the valuable trade of that part of the New World. The reports brought by these commercial adventurers were so favourable, that they obtained a charter of incorporation from Charles II., dated May 2, 1670; by which an exclusive trade to this Bay was granted to them, under the name of "The Governor and Company of Adventurers of England to Hudson's Bay."

This Company carried on a considerable trade from the Port of London to "all the straits, bays, seas, rivers, lakes, creeks, islands, shores, lands, territories and places whatsoever, with Hudson's Straits, and Hudson's Bay, as authorized by their charter, and have settled several small factories, to which the natives of these northern regions repair with their rich furs, skins and other commodities of the country, which they exchange for those of England.

The Company is managed by a *Governor*, J. H. Pelly, Esq., a *Deputy-governor*, Nicholas Garry, Esq., seven Directors, and a *Secretary*, William Smith, Esq., in their own Hall, a substantial and handsome building on the south side of Fenchurch Street.

The South Sea Company.—This celebrated Company must be well known to every reader of English history. It was established by royal charter of Queen Anne, September 8, 1711, ostensibly for the sake of commerce; but the ruin which its explosion spread all over England on the bursting of its bubble in 1720, appears not likely to be soon forgotten by the public, and its revolting details are to be found in every history of that iniquitous period.

The statute 9 Anne, c. 21, conveyed to this Company, the exclusive privilege of trading from the Port of London to the Pacific Ocean, and along the coast of America, from the River Orinoco to Cape Horn.

This privilege was taken away by the 47 Geo. III. c. 23, and in order to raise a guarantee fund for the indemnification of the Company, a duty of 2 per cent. *ad valorem* is laid by the 55 Geo. III. c. 57, upon all goods imported from within those aforesaid limits; with the exception of those from Brazil, Dutch Surinam, and the provinces of the Rio de la Plata; which duties are to cease when the guarantee fund is completed.

The office of the Company is in Threadneedle Street, and has been lately used by the large Banking-house of Smith, Payne and Smith, during the rebuilding of their spacious Bank, in King William Street, City.

Its officers are—the Queen, *Governor;* Charles Bosanquet, Esq., *Sub-governor;* Sir Robert Baker, *Deputy-governor;* twenty-one Directors, a Cashier, Accountants and Clerks; Nathaniel Simpson, Esq., *Secretary.*

Among other minor commercial Companies connected with the Port of London, before approaching the modern great dock Companies, are the Sierra-Leone Company, established in 1791; the Society of British North American Merchants, instituted in 1809; the Van Diemen's Land Company, in 1825; the Canada Company, in 1826, and a few others of less notoriety.

To show the amazing commercial trade of the Port of London, and its pre-eminence over its great rivals Liverpool, Glasgow, and Bristol, the following returns from the Customs, published in M'Culloch's 'Dictionary of Commerce,' is cited as incontrovertible evidence.

The returns are for one year ending the 31st December, 1835, and the four larger Ports only are selected. Ships belonging to the following Ports, namely,

London	2,828	Ships	566,152	Tons	32,392	Men
Liverpool	996	„	207,833	„	11,511	„
Glasgow	312	„	58,478	„	4,321	„
Bristol	281	„	42,913	„	3,899	„

So that the Port of London has nearly three times more vessels belonging to her than Liverpool, nine times more than Glasgow, upwards of ten times more than Bristol, and possesses nearly one-fifth of the whole shipping belonging to all the Ports of England and Wales together, which amounts to 14,823 ships.

Again, in forming an estimate of the value of the commercial property which floats on the waters of the Port of London, in the course of one year, let us refer to the Parliamentary Papers, published by the Board of Trade,* for the year ending 31st December, 1835, when we shall find, that the amount of

British ships that entered the Port of London in that year were	3,780	740,265	Tons.
Foreign ditto ditto	1,057	188,893	„
Forming a grand total of	4,837	929,158	„

which, valued only at £250 per ton for ship and cargo, amounts to the enormous sum of £232,289,500!

Well may Mr. M'Culloch exclaim, after reviewing his valuable tables and calculations, and this extraordinary amount of the commerce of the Port of London—"So vast an amount of shipping and commerce was never previously concentrated in any single port. London may be truly said to be *universi orbis terrarum emporium*—may her prosperity be as lasting as it is great!"

Another comparison between the entire commercial navy of France and England, particularly in reference to the Port of London, may be appropriately introduced in this place.

* Vol. V. p 46.

The entire commercial Navy of France, in the year ending December 31, 1836, as published by the Government of that country,* is as follows:—

800 Tons and upwards	1 Vessel	1,000 Tons
700 „ to 800	2 „	1,442 „
600 „ „ 700	2 „	1,247 „
500 „ „ 600	12 „	6,308 „
400 „ „ 500	68 „	28,902 „
300 „ „ 400	213 „	73,401 „
200 „ „ 300	575 „	141,166 „
100 „ „ 200	1,251 „	181,395 „
60 „ „ 100	1,477 „	116,683 „
30 „ „ 60	1,014 „	45,630 „
30 „ and downwards	10,634 „	87,839 „
	15,249	685,011

Whereas the number of ships and tonnage belonging to the British Empire, in the year ending the 31st December, 1835, were, for England alone,† 14,823 vessels=1,853,112 tons, exceeding the whole French Empire by 1,168,100 tons of shipping, and the Port of London is only 118,859 tons short of all France.

Add for Scotland	3,287 Vessels	335,820 Tons.
Ireland	1,627 „	131,735 „
The British Islands of Jersey, Guernsey and Man	563 „	39,636 „
Total of the United Kingdom and British Islands	20,300 „	2,360,303 „
Add for the British Plantations	5,211 „	423,458 „
Grand Total	25,511 „	2,783,761 „

To this gratifying statement, the following Returns of merchant and fishing-vessels, and of their tonnage, that have entered the Port of London from the year 1700 to 1835, will be appropriate, distinguishing those engaged in foreign trade, and the colliers and fishing-vessels from the coasters, taken from the Reports of the Committees of the House of Commons on the London Docks in 1796, of the Select Committees upon the Improvement of the Port of London in 1799, and in 1836.

YEARS.	FOREIGN TRADE. British		FOREIGN TRADE. Foreign		IRISH TRADE.		COLLIERS.		COASTERS.		FISHING VESSELS.	
	Vessels.	Tonnage.	Vessels.	Tonnage.	Vessels.	Tonnage.	Vessels.	Tonnage.	Vessels.	Tonnage.	Vessels.	Tonnage.
A.D. 1700	No return	No return	No return	No return	No return	No return	No return	No return	5,562	218,100	No return	No return
1702	839	80,040	496	76,995	do.	do.	do.	do.	No return	No return	do.	do
1750	No return	No return	No return	No return	do.	do.	do	do	6,396	511,680	do.	do
1751	1,498	198,023	184	36,346	do	do.	do.	do.	No return	No return	do.	do
1790	2,254	431,890	1,161	149,205	do.	do.	do.	do.	9,278	927,800	do.	do.
1795	1,841	398,317	991	189,136	do.	do.	do.	do.	11,964	1,196,400	do	do
1796	2,007	436,843	2,169	287,142	do.	do.	do.	do	10,629	1,323,532	do.	do.
1797	1,425	330,392	1,843	226,856	do	do.	do.	do.	10,781	1,360,823	do	do.
1798[a]	1,649	397,096	1,771	229,991	do.	do	3,289	749,813	6,844	500,636	do	do
1800 [b]	......	......	......	......	......	......	......	......	......	......	2,125	No record kept of the tonnage of vessels entering the Port with fish.
1810	......	......	......	......	......	......	......	......	......	......	3,033	
1820	3,354	655,239	856	122,619	420	43,891	5,921	No return	10,676	No return	4,949	
1830	3,910	714,229	1,268	207,500	797	105,409	6,994	1,413,243	11,316	918,049	4,831	
1835	3,780	740,255	1,057	188,893	1,163	160,076	7,980	1,617,530	11,328	987,376	4,153	

[a] In this year the colliers are first distinguished from the coasters in the Return, and are therefore most likely included among them in the former years, particularly as in this year the return of colliers 3,289 + to 6,844 coasters = 10,133 the whole return.

[b] The accounts for these years were destroyed in the fire at the Custom House in 1814.

* In the 'Tableau Général du Commerce de la France, avec ses Colonies et les puissance Etrangères, pendant l'anné, 1836' Par l'Administration des Douanes.'

† From the Custom-House returns printed in M'Culloch's 'Dictionary of Commerce.'

The following is also a Parliamentary Return of the number of colliers which entered the Port of London, from 1828 to 1835, with the amount of their cargoes in tons weight—namely,

1828	6,750 Ships	1,960,559 Tons.
1829	6,992 „	2,018,975 „
1830	7,108 „	2,079,275 „
1831	7,006 „	2,045,292 „
1832	7,528 „	2,139,078 „
1833	7,077 „	2,010,409 „
1834	7,404 „	2,078,685 „
1835	7,935 „	2,298,812 „

§ 7. The various Dock Companies in the Port of London.

Mr. M'Culloch, in his 'Dictionary of Commerce,' divides commercial companies into two great classes, namely, *exclusive* or joint-stock companies, and *open* or regulated companies.

Exclusive or joint-stock companies, he defines as companies having a certain amount of capital, divided into a number of transferable shares, managed by a body of directors, chosen by, and from, and responsible to the shareholders, and for their common and mutual advantage.

Open or regulated companies, he defines as companies or associations managed by directors, appointed by the members, but not possessing a common or joint-stock. Each individual pays a fine upon entering into the company, and often an annual contribution. A duty applicable to the business is also sometimes charged upon the goods imported to and from the countries with which they trade. The sums so collected are applied by the directors to fit out ambassadors, consuls, and such public functionaries as may be required to facilitate commercial dealings, or to build factories, maintain cruisers &c. The members of such companies trade upon their own stock, and at their own risk. A regulated company, says Mr. M'Culloch, is in fact a device for making those engaged in any particular branch of trade bear the public or political expenses incident to it. Such were the companies that formerly conducted the Levant, the African, and some before-mentioned other branches of trade belonging to the Port of London.

The nature and construction of the docks in the Port of London are discussed in their more proper place, the third Chapter of this work, this portion being appropriated to the commercial, not the constructive or scientific department of such works.

In consequence of the desperate system of marauding and plunder in the River Thames previous to the formation of docks, when vessels were obliged to unload in the stream into lighters, or alongside of wharfs, which was often accompanied by such personal violence, that Dr. Colquhoun did not unaptly name it River piracy,* the first docks in the River Thames were formed. These were the West India Docks, which were constructed by the earliest wet-dock company in the Port of London, under the title of "The West India Dock Company."

The vast amount of the West India trade, its immense capital, and its great importance to the Port of London, has been already shown in page 30. By inquiries instituted by a Committee of the House of Commons, it appeared in evidence, that the plunder on West India produce alone occasioned an annual loss to the proprietors of £150,000 a year, and £50,000 a year to the revenue. A Committee from the body of Planters, in a conference with the Minister in 1796, stated the amount of the depredations to be more than double that sum; but by a recapitulation of all the various losses to the West India proprietors alone, arranged by Dr. Colquhoun under seven distinct heads, it appears that the annual average loss to the proprietors, shipowners, shipmasters, consignees, and the revenue, previous to 1798, amounted to the almost incredible sum of £232,000 a year; to which, if we add the former sum of

* Dr. Colquhoun, in his curious work on the police of the River Thames, calculates the amount of these depredations to amount in one year, 1798, to £506,000 The number of depredators, among whom we reckon mates, inferior officers, and crews, revenue officers, watermen, lightermen, watchmen &c., to be 10,850, and opulent and inferior receivers, dealers in old iron, small chandlers, publicans, females &c. at 550.

£506,000 of depredations and plunder upon the foreign and coasting trade of our Port, amounted at the same time to the enormous sum of £738,000 a year.

Another singular view of this deplorable moral profligacy which then existed in the Port of London: Dr. Colquhoun says, " That it is but an act of justice to state," and no one knew the men he is speaking of better than that efficient Magistrate, " that the major part of them confine themselves entirely to this species of pillage; and that many of this class of men," like the buyers of smuggled goods, and the gentlemen and lady smugglers of the present day, without reckoning the professional, the bold smuggler, " would shudder at the idea of committing a burglary, or robbing on the highway."

The first attempt towards remedying this glaring piracy in the Port of London, was the establishment of the Marine Police in the River Thames, projected originally by Lieutenant Harriott of the Royal Navy, but completed and carried out by Dr. Colquhoun. Under the able management of these two magistrates this protection to the mercantile property in the Port was first intrusted.

This great engine of the preventive system was put into a state of immediate activity by the delivery of the cargoes of West India ships, through the medium of sworn foremen, and under the rules and regulations established by the magistrates and owners, all of which are fully detailed in the before-quoted work of Dr. Colquhoun. The new institution had much to struggle with before it was successful; men, apparently in respectable ways of commercial business, whose ill-gotten gain was put in jeopardy by its vigilance; men who had long iniquitously profited by the former practice of contracting for the delivery of ships, and other interested and perhaps more innocent persons, influenced by prejudice, joined in clamouring, that the new system was ruinous and destructive to the Port of London. The new system of River Police, and the large commerce which traded to and from the River Thames, received the strongest protection from the Duke of Portland, then His Majesty's Principal Secretary of State for the Home Department.

Among the proofs that this new system worked well, and preserved the trade of the Port of London from the depredations which otherwise would have ruined it altogether, are the acknowledgments, by certificate of approval, from the principal ship-masters trading to the Port; of the body of wharfingers; of the Committee of West India merchants; of the masters of American ships; of the masters of Hamburgh ships; of the general meeting of West India planters; of the buyers and factors of coals; of the Secretary of State; of the Commissioners of the Royal Navy; and many others, which are all to be found in full in Dr. Colquhoun's work. And among the results were, that watermen were no longer to be observed hanging about ships during their discharge; none of those infamous transactions with receivers, which are detailed in the Parliamentary Report before quoted, were then to be found, whereby the before-mentioned horrible pillage took place, and all the opulent and inferior receivers of twelve classes, who quickly moved off, and the mates, lumpers, coopers, scuffle-hunters, long-apron men, bum-boat men and women, river pirates, light horsemen, mud-larks, rat-catchers, and other depredators, vulgarly called tag, rag and bobtail, with all their skilful appendages of jiggers, bladders with nozzles, pouches, bags, sacks, pockets &c., whose departments and uses are so ably defined and described by Colquhoun, were no longer to be seen surrounding them at dusk and at low water. Then the pillage they committed was *excessive*, and it will not be a matter of wonder, since the general answer of all those vagabonds to the interrogatory of the magistrate, as to the means of subsistence, was, that *they worked at the water side.*

These names and occupations, which, like those of Othello, are now gone, and although at that time, almost in my remembrance, were as familiar as household words are now, thanks to the framers of those laws, and the founders of those docks, and to the perpetual advantage of our splendid and capacious Port, in want of a scuffle-hunter's glossary, or a light horseman's vocabulary, Captain Grose's to wit, to enable us of the present day to understand them.

As a further proof of the efficacy of the system, the sales at the Custom-House of the sugar, coffee, and other West India produce, seized from plunderers of every description in the Port of London,

diminished from being very extensive, shortly to nearly nothing. The Custom-House sales of such plundered and seized sugar, for the year previous to the establishment of the Marine Police, according to their own documents,

	Sugar	*Coffee.*
Amounted to	28,446 lbs	13,577 lbs.
But for the next year to only	9,370 „	3,716 „
Reduction of seizures of plunder	19,076 „	9,861 „

At length, by means of every aid which could be derived from an extensive judicial procedure, in which all the obstructions to the full attainment of a complete preventive system were accurately marked, the materials which had, from the before-mentioned causes, been progressively collecting, were ultimately arranged and digested into the form of a Parliamentary Bill, founded on the evidence given before the Committee of the House of Commons by the West India trade, having as then only the protection of the commerce of that body, for which it had been originally devised.

The beneficial effects of these even incipient proceedings were so great, in respect to other branches of trade as well as to that of the West India merchants and planters, that many of the most respectable merchants and shipowners concerned in the general commerce of the Port of London, suggested a wish, that a system which had been found to work so advantageously to the West India trade, should be extended to the entire commerce of the Port of London, and that a permanent fund should be raised under parliamentary authority for its maintenance.

The Committee appointed to attend to the general interest of the West India trade, readily acceded to the measure, and soon after a proposal was drawn up and issued to the public "for raising a fund from the whole trade of the Port of London, with an estimate of the amount, proportioned upon the tonnage, according to the value of the goods imported and exported, and the advantages each branch is supposed to derive from the protection afforded by the Marine Police Institution."

This proposition was transmitted forthwith by the Chairman of the West India Committee to the governors and directors of all the various chartered and incorporated companies, and to the chairman or principal merchants concerned in every other branch of commerce connected with the Port of London, for the purpose of carrying its propositions into effect.

It was therefore resolved to re-model the bill, to introduce into it the financial part of the system which had not been contemplated, and to adopt into it all the various enactments and provisions which were necessary for the general interest of the whole commerce of the Port.

It was thought at this time, that the formation of docks, in the Port of London, would supersede the necessity of a police; but facts have since proved, that those persons who then thought that equally conclusive reasons may be offered why those establishments would increase that necessity, judged rightly.

These various circumstances led to the establishment of

THE WEST INDIA DOCK COMPANY

Which owes all its original powers and privileges in the *Port of London* to the express letter of the statute 39 Geo. III. c. 79, generally called the *Wet-Dock Act.*

The preamble to § 38 of this Act recites, "That the ships in the West India trade frequently arrive at the Port of London in large fleets, and occasion great crowding, confusion and damage therein; that great obstruction and delays arise from their cargoes being carried in lighters to the legal quays, and that in the passage thither, such cargoes are subjected to pilfering and fraud, whereby the owners sustain great

loss, and the revenue is much injured; and that if wet-docks were made in the Isle of Dogs with legal quays, wharfs and warehouses attached thereto, for the reception and discharge of vessels in the West India trade, much additional room would be given to the rest of the shipping using the Port; and the West India produce might be effectually secured from loss by theft and other causes, and the public revenue greatly benefited. That it is therefore expedient that such docks, quays, wharfs and warehouses &c. should be forthwith made. That several persons have agreed to form a Company for this purpose, and have entered into a subscription, for the purpose of raising £500,000 as a capital for carrying the works into execution."

These docks occupy the isthmus that formerly connected the Isle of Dogs with Poplar (see Plate 13), and formerly consisted of two docks, the north or import dock, and the south or export dock; but by statute 10 Geo. IV. c. 24, the West India Dock Company purchased the City Canal of the Corporation of London as hereinafter-mentioned,* which they have named the South Dock, and use it for laying up of ships for repair &c., and have since added at the eastern end a very extensive pond for timber in bond. *(See the large Chart.)* The description of the construction and arrangement of this, as well as of the other docks &c., are to be found in the third or scientific Chapter of this volume.

This spacious and magnificent Establishment was formed by subscription, the property being vested in the West India Dock Company, the affairs of which are under the management of a Chairman, Deputy-chairman and twenty-one Directors, and their capital, according to Mr. M'Culloch, is £1,380,000.

This Company was so eminently successful, that after making dividends of £10 per cent. for nearly twenty years, and finding they had a surplus of accumulated fund amounting to nearly £400,000, they diminished their charges to the public at the suggestion of the Committee of the House of Commons, on the foreign trade of the country, so as to give the trade using the docks the benefit of the surplus fund, which was reduced to £100,000 before the 30th January, 1826. Latterly the Company have been obliged, says that excellent authority, Mr. M'Culloch, in consequence of the competition of the other companies, to make further reductions of dividend. It now amounts to £5 per cent., and the Company's stock is at par.

The Company has been further regulated by statute 1 and 2 Will. IV. c. 52, which enacts the rules and regulations to be observed, and rates to be paid, by the shipping frequenting the West India Docks, as well as the rules and orders to be observed by masters, pilots and other persons having the charge of ships, vessels, lighters or craft, coming into, lying in and going out of the West India Docks.

The Company's Moorings.—The moorings in the River, within the circuit of a radius of 200 yards of each of the entrances at Blackwall, and that into the Limehouse Basin, and within 150 yards of the Limehouse entrance of the South Dock *(see the larger Chart)*, are reserved from the usual privileges of the Port of London, for the exclusive use of vessels entering into, or which have recently come out of the Docks.

The other regulations, orders, rates &c. are to be found in the before-mentioned Acts of Parliament, M'Culloch's 'Dictionary of Commerce,' and at their offices in Billiter Square, Fenchurch Street. The present principal officers are—Andrew Colville, Esq., *Chairman;* George Hibbert, Esq., *Deputy-chairman;* Henry Longlands, Esq., *Secretary;* and Captain Charles C. Parish, *Dock-master.*

THE LONDON DOCK COMPANY

Was the next incorporated Society for the improvement of the Port of London, by means of wet-docks. The proprietors of this Company were incorporated, in 1800, by statute 41 Geo. III. c. 116, under the title of "The London Dock Company." The Company's docks are situated in Wapping, and were principally intended for the reception of ships laden with wine, brandy, tobacco and rice. (See Plate 9.)

* Page 41.

The capital of the Company, according to Mr. M'Culloch, amounts to £3,238,310. 5*s.* 10*d.* A considerable portion of this vast sum, and of a further sum of £700,000 borrowed, was required for the purchase of 1,300 houses, and attached trades, besides the freehold ground on which they stood in the densely populated parishes of St. Botolph, Aldgate, St. John's, Wapping, St. George's, Middlesex, and St. Paul's, Shadwell.

Their present dividend, says Mr. M'Culloch, is $2\frac{1}{2}$ per cent., and a share of £100 is worth about £55. 10*s.* This wealthy and important Dock Company is governed by a *Chairman*, John Catley, Esq., a *Deputy-chairman*, William King, Esq., twenty-three other Directors, of whom the Lord Mayor, for the time being, as Conservator of the River Thames, is one; J. D. Powles, Esq., *Secretary*, and Captain Parish, *Dock-master*. Their office is in Bank Buildings.

The rules, regulations &c. are to be found as before-mentioned for the West India Dock Company.

THE EAST INDIA DOCK COMPANY

Is the next Association, chronologically, in the history of the improvements of our Port, and was originally incorporated, in 1803, by statute 44 Geo. III. c. 24, for the purpose of making wet-docks at Blackwall, and within the parishes of St. Dunstan Stepney, and Bromley St. Leonard, in the county of Middlesex, for the reception of the ships employed in the service of the East India Company, whose vessels, from their large size, were prohibited from delivering their cargoes elsewhere, except a portion in Long Reach, when they wished to lessen their draught of water, under a penalty of five hundred pounds. There was, however, a similar power granted to the Commissioners of the Customs, in the event of these docks being full. Outward-bound ships were also compelled to load either in these docks, or below Limehouse Creek, under a penalty of two hundred pounds.

On the cessation of the East India Company from being any longer a commercial body, the Directors of this Incorporation opened their docks to vessels of every trade that frequented the Port of London. This Company have also, since the said period, purchased three of the largest bonding-warehouses, formerly belonging to the East India Company, in the heart of the City, in which they warehouse and show tea and other goods on the same terms as the other docks.

The Company's capital, according to Mr. M'Culloch, including the cost of the City warehouses, is £623,000; the present dividend is £6 per centum; and the stock was, in January, 1837, worth from £116 to £117.

For rates, rules, orders, regulations &c., the inquiring reader is referred to the before-mentioned authorities for other docks.

The present principal officers are—William Routh, Esq., *Chairman;* Archibald Hastie, Esq., *Deputy-Chairman;* Captain Drew, *Dock-master;* James Walker, Esq., P.I.C.E., *Engineer;* K. D. Martin, Esq., *Surveyor;* Thomas Baker, Esq., *Secretary.*

THE ST. KATHERINE DOCK COMPANY.

This Company was incorporated by the Act 6 Geo. IV. c. 105, (local,) and the docks were opened on the 25th October, 1828. They are situated immediately below the Tower (*see the large Chart,* Plate 1 and Plate 4), and are consequently the nearest of any of the docks to the Custom-House, the Royal Exchange and other places of great commercial resort. The capital raised by shares, according to Mr. M'Culloch, amounts to £1,352,800; but an additional sum of £800,000 has been borrowed on the security of the rates for the completion of the works, and the purchasing of the property with River frontage from the Tower to the corner of Lower East Smithfield.

The rules, regulations, rates &c. of this Company are to be found in the before-named Act of

Parliament, in Mr. M'Culloch's 'Dictionary of Commerce,' and copies thereof may be had at the Company's Office, St. Katherine's.

The present principal officers are—Thomas Tooke, Esq., *Chairman;* G. G. H. Larpent, Esq., *Deputy-chairman;* G. C. Glyn, Esq., *Treasurer;* Sir John Hall, K.H., *Secretary.*

THE COMMERCIAL DOCK COMPANY.

The docks &c. belonging to this Company are nearly opposite the western or upper end of the West India Docks (see Plates 1 and 16), and cover one hundred acres, sixty acres of which are *water*, appropriated for the reception of ships to unload or lay up in, and for the floating of timber, a large quantity of which is always deposited there. The forty acres of land is at present appropriated to the bonding of deals, staves &c.; and there are several large granaries capable of holding 70,000 quarters of corn, which a few months ago were all full. The largest of these docks (see Plans) was originally the *Greenland Dock*, and was purchased by the present Company, who have since improved and extended it, at an outlay of £400,000. Large quantities of timber, deals, staves &c. from British America, and from the Baltic, are annually floated or landed in these docks; and they are declared by Government to be a place of *special security* for corn and seed.

The present principal officers of this Company are—Benjamin Shaw, Esq., *Chairman;* R. H. Marten, Esq., *Deputy-chairman;* Benjamin Shaw, Esq., *Treasurer;* H. K. Smithers, Jun., Esq., *Secretary;* David Waters, Esq., *Superintendent.* Office, 106, Fenchurch Street.

Before concluding this section, a few lines may be appropriately devoted to the warehousing system; or the provisions made for lodging imported articles in public warehouses, at a reasonable rent, without payment of the duties on importation till they be withdrawn for home consumption. If re-exported no duty is ever paid.

This system, which is acknowledged by Dr. Adam Smith, Dean Tucker, Professor M'Culloch, and other eminent authorities, to be founded on the sound principles of political economy, was originally proposed by Sir Robert Walpole, in his famous Excise scheme in 1733, which nearly caused a rebellion, but the plan was not finally adopted till 1803. This obvious and signal improvement, the greatest, says Mr. M'Culloch, that has been made in our commercial and financial system, is founded on one of Adam Smith's celebrated maxims on the subject of taxation, that "every tax ought to be levied at the time and in the manner that is most likely to be convenient to the contributor to pay it."*

The statute of 43 Geo. III. c. 132, laid the foundation of this system; but it was much improved and extended by subsequent statutes, the regulations of which have been embodied in the Act 3 and 4 Will. IV. c. 57, which came into effect on the 1st September, 1833. This Act empowers the Commissioners of the Customs, under the authority of the Lords of the Treasury, to nominate the ports at which goods may be warehoused without payment of duty, and the warehouse in which particular descriptions of goods may be deposited. It also fixes the time during which goods are allowed to remain in the warehouse; and prescribes the regulation as to their removal from port to port, their sale and stowage in the warehouse, the remission of the duties in case of loss by accident, the allowance for waste &c. The principal sections of this important commercial Act, are—3. Warehouse of special security by appointment: 9. Sale of goods in warehouse by proprietor to be valid: 11. Goods fraudulently concealed or removed to be forfeited: 13. Goods to be carried to warehouse under authority of officers of Customs: 14. Goods to be cleared in three years, and ship stores in one year: 15. In case of accident, duty to be remitted: 21. Goods may be removed to other ports to be re-warehoused: 24. How to discharge the bond: 26. On arrival, after forms of re-warehousing, parties may enter to export &c.: 35. Silks, linens &c. to be delivered out of warehouses to be cleaned if necessary: 41. Embezzlement and waste by officers to be made good to proprietor, and sundry other useful provisions, for which the reader is referred to the Act itself, and to an excellent abstract in Mr. M'Culloch's 'Dictionary,' under the head "Warehousing System."

* 'Wealth of Nations,' vol. iii p. 368

§ 8. AN ACCOUNT of Vessels which can be accommodated in the Port of London, between Blackwall and London Bridge, so that a free passage-way of 300 feet be at all times open; specifying the numbers and situations proposed for the Tiers, the greatest number of Vessels to be allowed at each Tier; the depth of Water at the respective Tiers; and nature of the Anchorage. Taken from the Report from the Select Committee of the House of Commons, on the Port of London, 1836.

SOUTH SIDE	Depth of Water Inside (Feet)	Number of Ships	Depth of Water Outside (Feet)	NATURE of ANCHORAGE
1. Battle Bridge . ... Tier	9	6	11	Hard Gravel and Clay. (Nos. 1–7)
2. Pickle Herring ...... Upper do.	10	5	12	
3. Ditto .. . .Middle do.	12	5	13	
4. Ditto ... . Lower do.	11	5	12	
5. Limekiln .. ..Chain	7	7	13	
6. Garlands .. . . do.	10	8	10	
7. Old Rose .... .Tier	9	7	13	
8. Horselydown ... . Upper do.	10	7	10	Black, Trashy and Clay (Nos. 8–22)
9. Ditto . ... Middle do.	11	6	11	
10. Ditto ....Lower do.	10	7	12	
11. Mill Stairs .. .. do.	10	6	12	
12. Bishop's ... . Chain	10	6	11	
13. East Lane, Upper Tier .. .. (Steamers)	11	2	14	
14. Ditto . . .Lower do. (Steamers)	11	2	14	
15. Fountain Dock do. .... (Steamers)	11	2	14	
16. Ditto Corn Road	12	6	16	
17. Ditto Hole ....Tier	9	6	14	
18. Cherry Garden . . ..Upper do.	11	6	12	
19. Ditto .... .Middle do.	11	6	12	
20. Ditto . . . .Lower do.	10	6	14	
21. Rotherhithe .. . .Upper do.	10	7	15	
22. Ditto ....Lower do.	11	7	15	
23. King's Stairs .... do.	11	7	15	Hard Gravel and Clay. (Nos. 23–29)
24. Princes Stairs .... do	11	8	17	
25. Trinity ... . do.	11	7	15	
26. Church Hole ... . do.	12	8	16	
27. Hanover Hole .... do.	12	20	16	Collier Tiers: Number of Colliers 58. (Nos. 27–29)
28. Mill Hole ... .Upper do.	12	20	16	
29. Ditto . . . .Lower do.	13	18	15	
From the Commercial Docks, down to the Middle Water Gate, below Her Majesty's Dock Yard, Deptford, is occupied by Government, in which the Harbour-masters regret not having power to lay Ships	..		.	Mud and Gravel.
From the Middle Water Gate to Deptford Creek, four Tiers, eight Ships at each Tier	22	32	26	
Total of Vessels, south side . .		244		
From Deptford Creek to the Bight, below the Town of Greenwich, is used by Colliers detained, for want of sufficient room in the Collier Pool for their accommodation, and other Vessels stopping for the tide	13		17	Gravelly Soil.

NORTH SIDE	Depth of Water Inside (Feet)	Number of Ships	Depth of Water Outside (Feet)	NATURE of ANCHORAGE
1. Eel . ...Chain	9	6	9	Gravel and Clay. (Nos. 1–15)
2. Yarmouth . . .. do.	9	6	10	
3. Dublin .. .. do.	11	6	13	
4. Tower .... Upper Tier	11	6	13	
5. Ditto . . ..Middle do.	9	5	14	
6. Ditto ... .Lower do.	9	5	13	
7. Iron Gate ... . . . do.	10	6	13	
8. Alderman's .. .. ..Upper do.	9	6	11	
9. Ditto .. . .Middle do.	9	7	11	
10. Ditto . ... Lower do	8	7	9	
11. Hermitage .. . Upper do	9	7	10	
12. Ditto . ... Middle do.	9	7	12	
13. Ditto ....Lower do.	11	7	12	
14. Union Stairs . . ..Upper do.	9	7	12	
15. Ditto ....Lower do.	11	6	16	
16. Cole Stairs .... do.	12	20	16	Collier Tiers. (Nos. 16–20) Number of Colliers 89; Do. south side ... 58; Total .. 147; Ditto of Coasters 283; 430
17. Bell Wharf .. .. do.	12	20	16	
18. Stone Stairs . . .. do.	14	18	16	
19. Ratcliffe Cross .. Upper do.	10	16	17	
20. Ditto . .... Lower do.	12	15	17	
21. Limehouse Hole .. ... do.	10	7	16	Rocky and Clay. (Nos. 21–24)
22. Canal ... . do.	10	8	16	
23. Below ditto ... ... do.	13	9	14	
24. Ditto ditto second .... . do.	9	10	12	
From the second Tier below the Canal, down to Mellish's Wharf, is shallow water, and only used by foreign Vessels of light draught of water	...	..	.	Hard Gravel and Mud.
The anchorage from Saunders' Ness, down to the Blackwall entrance to the South Dock, is occupied by Steam Vessels laying up, and by detained Colliers, when there is not sufficient room for them in the Collier Pool, and by other Vessels stopping for the tide	...	. .	..	Mud, Clay and Gravel.
Average depth of Water, from eight to ten feet.				
The buoys and moorings at the entrance of the West India Docks are used by Vessels going in or out of the said Docks.				
Average depth of Water, from seventeen to twenty-two feet.				

In making the above Return to your Committee, the Harbour-masters beg to state, that from strong wind, tides and swing of the moorings, three hundred feet of navigation cannot at all times be kept.

(Signed) JOHN FISHER.
CHARLES ROWLAND.
WILLIAM MAYOTT
JAMES ELMES, *Surveyor of the Port of London.*
MALCOLM DUNNETT, JUNIOR, *Clerk.*

HARBOUR-MASTERS OFFICE, ST. KATHERINE'S,
February 27, 1833.

§ 9. During the latter years of the late long and expensive war, and down to 1825, the charges on account of docks, lights, pilotage &c. in the Port of London were exceedingly heavy. In that year most of the dock monopolies in our Port expired, and a very great reduction has been made in all their charges, to the great benefit of its commerce.

Previous to the year 1833, certain port or tonnage duties were imposed on ships frequenting the Port of London, partly to pay the expenses of the harbour service, and partly to create a fund for the improvement of the Port. These duties are known in the Corporation accounts by the name of the "*Tonnage Duty Fund.*"

The Corporation of London, having sold, in the year 1829, the City Canal to the West India Dock Company for £120,000, and the sum advanced by the public for the improvement of the Port having been repaid, it was judiciously resolved to reduce the Port duties to the lowest rates capable of defraying the necessary expenses, which was accomplished by the 4th and 5th Will. IV. c. 32, making a vast reduction of tonnage duties. This new scale of tonnage duties took place on the 25th July, 1834, and are, on an average, says Mr. M'Culloch, from four to six times less than formerly. This is a very moderate estimate of the reduction, for what in the former duty was 7*d.* is now three-farthings, and what formerly was 5*d.* is now one halfpenny. The Trinity House dues and charges on the account of lights and pilotage have been also materially reduced, and in the article of pilotage, which is still too high, will be still farther reduced. The oppressive and troublesome charges of package, scavage, garbling &c. were also given up by the Corporation in 1833; and in the opinion of Mr. M'Culloch, and other eminent authorities in such matters, the Port of London charges and dues, considering its accommodations and safety of entrances, are quite as reasonable as those in any other port of the Empire or of the world.

§ 10. As a general summary of the rights, privileges, functions, powers and jurisdiction of the Corporation of London over its own Port and River, I cannot do better than cite the paper delivered in to the Select Committee of the House of Commons on the Port of London, by the late estimable man, Robert Finch Newman, Esq., the City Solicitor, in reply to a statement *contra*, made by Charles Jones, Esq., the Solicitor of the Admiralty. This learned authority admitted, that although the Crown, by its prerogative, has the property in the sea and in all navigable rivers, he contended, on the high authority of 4 Comyn's Digest, p. 260, head *Navigation*, and again in the same volume, page 192, that "by grants from ancient Kings, the Mayor &c. of London have the property of the Thames, *tam soli quam aquæ;*" and it had been decided by the same authority, vol. i. p. 276, head *Admiralty*, "that the jurisdiction of the Admiralty *does not exist upon the River Thames.* In the 39th year of Queen Elizabeth, the Lord High Admiral contested the City's jurisdiction, but with no other success than to strengthen and confirm, by the solemn authority of a verdict, the Lord Mayor's authority as Conservator of the River Thames.

The Admiralty Solicitor having stated in his Report, that at common law, and by the statute 1 Eliz. c. 17, s. 6, the Lord High Admiral has the Conservancy of the great and navigable rivers, and that this right is confirmed by the statute 54 Geo. III. c. 159, the City Solicitor replied, that the common law does not prevail against the City's immemorial rights and usages; and added, that so far from the statute 1 Eliz. c. 17, s. 6, conferring upon the Lord High Admiral the Conservancy of the River Thames, it established the fact of the Lord Mayor being the Conservator, and referred the Honourable Committee to the words of the Act, which are, that "the Lord High Admiral of England and *the* Mayor of the City of London for the time being, and all and every other person and persons, bodies politic and corporate, which by grant or other lawful ways and means lawfully have or ought to have any conservation or preservation of any rivers, streams or water, or punishments and corrections of offences committed in any of them, shall have full power and authority &c. &c." It is evident, said the City Solicitor, from this, that the name of the Lord Mayor was here inserted expressly on account of his jurisdiction on the Thames and Medway, for he has no conservancy whatever over any other river. And that the statute of 54 Geo. III. c. 159, merely confers powers upon the Lord High Admiral with reference to His Majesty's moorings, docks, dock-yards, arsenals and wharfs, and spaces along the sides thereof, and does not in any way interfere with the Lord Mayor's rights as Conservator; in fact, by the section 28 of the same statute, all rights of conservancy are expressly saved.

The charter of James I. before quoted, dated 20th August, 1606, does not contain a grant of the conservancy of the River, as implied to have been the case, and also to have been the first grant, by the Solicitor to the Admiralty; but merely recognises it as the immemorial right of the City, and as such ratifies and confirms it. So also the City's rights on the River Thames and in the Port of London were recognised by charter, so early as in the reign of Richard I.; and in a charter of King John they are described as "ancient liberties." They are also recognised by charters both before and after that of 3 James I., in one of which, namely, that of the 23 Henry VI., the Crown granted to all Citizens of London all the *common soils, encroachments and improvements in the water of Thames*, together with the *profits* of the same encroachments and improvements, and that they might thereafter improve and farm them, and the rents thereof enjoy to themselves and their successors for ever.

The rights of the Corporation of London in their River and Port, are also corroborated by several Acts of Parliament, extending from the reign of Richard II. to the present time; by numerous reports and other ancient authorities, produced by Mr. Newman; and by the continuous exercise of such rights as are mentioned in the first Chapter of this work, page 2, but more particularly by the holding Courts of Conservancy, in the punishment of offenders, and in the receipt of fines imposed by that Court to the City's own use, without accounting to the Crown.

With respect to the obtaining fines and rents for licences to make wharfs and embankments, such licences are never granted where such embankments are prejudicial to the public, nor till a view has been taken, previous to such licences, by a Sub-Committee and the principal Officers of the Conservation and Harbour-service. They are moreover revocable at pleasure; the sums received for them, with much larger sums from the Tonnage duty and from the Corporation funds, are annually applied to the purposes of the conservancy and improvement of the Harbour and River.

Mr. Newman cites, that such licences have been granted from a very early period, and that the right of the Corporation to grant such licences, and to receive such fines and rents, has been repeatedly acknowledged by various branches of Her Majesty's service, who have applied for and obtained such licences upon payment of rents to them; and, amongst others, the Commissioners of Her Majesty's Navy, the Board of Ordnance, the Commissioners for Victualling Her Majesty's Navy, and the Corporation of the Trinity House;—and, as if these were not sufficient proofs, the learned Solicitor adds, that the Act 3 and 4 Will. IV. c. 65, empowers the Lord High Admiral to execute certain works on the bed and soil of the River Thames, about Woolwich, *the consent in writing of the Lord Mayor of the City of London, as Conservator, is expressly required to be obtained, and his other rights as Conservator are saved and reserved.*

So jealous are the Corporation of these, their ancient rights and privileges, over their own River and Port, and such respect is paid to them by the Legislature, that the first and only instance of the interference of any part of the Government with them was, when the Board of Admiralty, in the Parliamentary Session of 1836, required the introduction of a clause in the Greenwich Pier Bill, providing that the works should be subject to that Department. The Corporation considered this provision as an infringement of their rights and privileges, and a clause was consequently prepared by their law-officers, and was substituted for the clause introduced by the Board of Admiralty.

The Corporation of London do not dispute the control of the Crown over the River and Harbour of Thames, with reference to the public safety; but it is clear and indisputable, from the before-mentioned charters and Acts of Parliament, that the soil and freehold of the River is vested in the Corporation by grant from the Crown, and their right over the same has been continually exercised, from the date of our earliest records to the present time.

CHAPTER III.

ON THE BRIDGES, DOCKS, PIERS, QUAYS, EMBANKMENTS, MOORINGS, AND OTHER SCIENTIFIC WORKS; TIDAL AND OTHER OBSERVATIONS &c., IN AND APPERTAINING TO THE PORT.

SECTION 1.—*Account of the earliest Engineering Works in the Port.* — 2. *London Bridge.* — 3. *The St. Katherine Docks.* — 4. *The London Docks.* — 5. *The Thames Tunnel.* — 6. *The Grand Surrey Canal.* — 7. *The Regent's Canal and Basin.* — 8. *The Bromley Canal or Limehouse Cut to the River Lea.* — 9. *The West India Docks.* — 10. *The Commercial Docks.* — 11. *The East India Docks.* — 12. *The Queen's Moorings, Deptford Reach.* — 13. *The Corporation New Chain Lighter.* — 14. *Mooring-chains, Stones &c.* — 15. *Section of the River Thames, from London Bridge to Bugsby's Hole, with Tidal and other Scientific Observations.* — 16. *Various Methods of Mooring Ships in the Collier Pool.* — 17. *Account of the Steam Navigation and Steam Vessels belonging to and frequenting the Port of London.*

HAVING described, in the preceding Chapters, the natural Port of London, the next and last division of our survey is, its artificial Port, or that, as it now is, improved by the art and skill of the Architect and Engineer. One of our ablest writers, on the commerce and commercial navigation of the whole world, Mr. M'Culloch, says, in his 'Dictionary of Commerce,' article *Harbour*, that "London stands at the head of the River Ports of Great Britain. Considering the limited course of the Thames, there is probably no river that is navigable for large ships to so great a distance from sea, or whose mouth is less obstructed by banks. London is mainly indebted for the unrivalled magnitude of her commerce to her favourable situation on this noble River; which not only gives her all the advantages of an excellent Port, accessible at all times to the largest ships, but renders her the emporium of the extensive, rich and populous country comprised in the basin of the Thames."

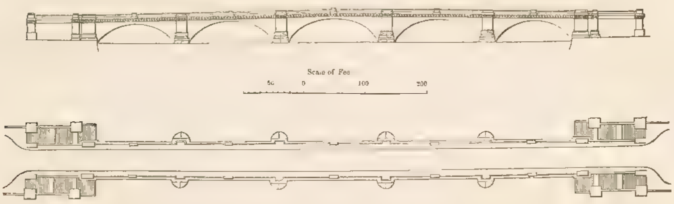
Of the Mersey, now the second commercial river in the British Empire, the same writer says, that it is more incommoded by banks than the Thames, and is in all respects inferior, as a channel of navigation, to the latter. The Port of Bristol, the next river port in the United Kingdom, he says, is accessible to the largest ships, owing to the extraordinary rise of the tide; and of Glasgow, that the shallowness of the Clyde from Greenock up to Glasgow, is a serious drawback upon the commercial prosperity of the latter. "Large sums," he says, "have been expended in attempts to contract the course, and to deepen the bed of the river; and they have been so far successful, that vessels of 150 tons burden may now, generally speaking, ascend to the City at all times of the tide. But there seems little probability of its ever becoming suitable for the navigation of ships of pretty large burden."

§ 1. The earliest engineering operations in the Port of London, of which there is any record, is the draining of the extensive marsh, which reached from the Thames to Camberwell hills, by the Romans, until by drains and embankments they recovered all the low lands in Southwark and its vicinity.

In the reign of Henry VI., when the Port of London had assumed a considerable degree of commercial importance, an Act of Parliament was passed in the year 1424, for improving the navigation of the River Lea, which was deemed of much importance to the supply of London with corn, meal, malt and other agricultural produce. In much earlier days its trade too must have been considerable, for a royal charter of 31 Edward I.* recites, that his merchants trade with Germany, France, Spain, Portugal, Navarre, Lombardy, Tuscany, Provence, Catalonia, "our Dukedoms of Aquitain, Thoulouse, Turenne, Flanders, Brabant" &c.

* From the Rolls in the Tower of London, Num. 44.

§ 2. The Port of London begins, as before mentioned, at London Bridge, an elevation and plan of which from drawings, kindly furnished by Sir John Rennie, are here given.



This handsome and scientific structure is the first bridge that crosses the Thames, in coming up the River from the sea, and is the terminus of the Port, reckoning from its mouth. (See page 16.)

In the year 1821, proceedings were instituted by the Government, in the House of Commons, relative to the building of a new bridge over the Thames instead of the old one, which had been long dangerous to the navigation of the River, and inefficient in every respect for its destined purpose. A Committee was immediately appointed, who proceeded to take evidence, and to make a Report, which concluded by recommending a bill to be prepared for that purpose, and to be presented to the House at their next Session. This was followed by a survey of the River, from the lower side of the old bridge to Old Swan Stairs, at the expense of the Corporation, and by the offer of premiums for the three best designs. The premiums were awarded, but one of the designs, made by the late John Rennie, Esq., who did not enter the competition, was ultimately ordered to be executed on the recommendation of the Committee of the House of Commons.

The building of the new bridge was then officially referred to Parliament by order of the Corporation in February, 1823, when a Select Permanent Committee of thirty Commoners, from the whole body of the Court of Common-Council, together with the Lord Mayor and all the Aldermen, and the Chairman of the Sub-Committee of City Lands, was appointed as comptrollers of the works, under the title of "The London Bridge Committee." This Committee is still in existence, but as the bridge is finished, and the new approaches thereto incomplete, they are now called "The London Bridge Approaches Committee."

This Committee, aided by the law-officers of the City, presented a bill to the House of Commons, which, after much discussion and alteration in the Committee of the House, was finally arranged, passed both Houses of Parliament, and received the Royal Assent on the 4th July, 1823, the 4th Geo. IV. It is entitled "*An Act for the rebuilding of London Bridge, and for the improving and making suitable approaches thereto.*"

The first pile of the new bridge was driven on Monday, March 15, 1824, near to the southern end of the old bridge, opposite the second arch from the Southwark side, at the eastern end of the coffer-dam. The works were then began, by taking down the old houses near the bridge-foot, and other necessary operations.

After the death of Mr. Rennie, in 1826, the works were carried on till the completion of the bridge by his son, the present Sir John Rennie, the contractors being Messrs. William Jolliffe and (Sir Edward) Banks. The first stone was laid on the 15th June, 1825, by the Lord Mayor (Garratt), accompanied by the Duke of York; many Peers and Members of Parliament; the President and Committee of the Royal Society, which had been appointed to investigate several scientific matters connected with the new undertaking; the Aldermen, Common-Council and City Officers; the London Bridge and the Bridge House Estate Committees, and the Harbour-masters and Surveyor of the Port of London; the whole formed into a splendid procession to the scene of action.

The stone was laid in the first coffer-dam, which surrounded the first river pier of the southernmost arch, with the usual ceremonies. It was a beautifully wrought cube of Haytor granite, five feet long, three feet six inches wide, and two feet ten inches deep, weighing upwards of five tons.

The exterior of this bridge is constructed of three sorts of granite, wrought in a beautiful and scientific manner. The eastern side with the purplish Aberdeen granite, the western side with the light grey Haytor granite, and the voussoirs of both sides with both sorts, and an admixture of the red-brown granite of Peterhead. The fillings in are of Bramley Fall, Derby and Whitby stone.

The elevation of the bridge (see the wood-cut, page 44) consists of five elliptical arches, the central one of which is one hundred and fifty-two feet in span, and twenty-nine feet six inches in height. The adjoining piers are twenty-four feet in width; the arches north and south of the centre arch are one hundred and forty feet span, and twenty-seven feet six inches rise; the piers between them and the two land arches are twenty-two feet thick; the two arches nearest the London and the Southwark shores are one hundred and thirty feet span, and twenty-four feet six inches rise; and the abutment piers on either side, seventy-three feet thick.

The arches and piers are surmounted by a bold projecting block cornice, describing the curvature of the roadway, and a solid parapet. At each extremity, and on both sides of the bridge, are two straight flights of granite stairs, as shown in the Plan, twenty-two feet in width, leading from the bridge to the water.

The total width of the water-way is six hundred and ninety-two feet; the length of the bridge, including the abutments, nine hundred and twenty-eight feet; the width from outside to outside of the parapets, fifty-six feet; the width of the carriage-way, thirty-six feet; of each footpath, nine feet; and the total height of the bridge in the centre, above low-water mark, fifty-five feet.

§ 3. In leaving our fine bridge to the westward, at the eastern extremity of the Port of London, the next large scientific works are the wet-docks appertaining thereto, and those nearest to the bridge are

THE ST. KATHERINE DOCKS,

the Company for the construction of which, and its history, are described in Chapter II., page 38. The space included within the outer wall is about twenty-four acres, nearly eleven of which are water. They consist of two docks (see Plate 4), communicating with each other by a basin, and are surrounded by large and lofty stacks of warehouses, and by wide and commodious quays. They occupy the space from Tower Hill on the west, to Burr street, East Smithfield, on the east. The lock leading from the River is one hundred and eighty feet in length, and forty-five feet in width, between the entrance gates (see Plate 6), and is so constructed that vessels of upwards of six hundred tons burden may pass and repass three hours before high-water, so that outward-bound ships from these docks can reach Blackwall before the tide begins to recede. The depth of water at the top of the spring tides, on the sills, Trinity datum, is twenty-eight feet; at the dead neap tides twenty-four feet; at low water spring tides, ten feet; and at low water neap tides, twelve feet; so that vessels of upwards of eight hundred tons register, are docked and undocked without difficulty, and the depth of the water at the entrance exceeds that of any other wet-dock in the Port of London, as may be seen by the following table:—

	Depth of Water on the outer Sill of Gates at low water Spring Tides, Trinity datum.	
	Feet.	*Inches.*
St Katherine Docks	10	0
London Docks, Hermitage entrance	3	0
,, ,, Wapping ditto	5	0
,, ,, Shadwell ditto	6	6
Regent's Canal, entrance of Basin	1	0
West India Dock, Limehouse entrance	4	3
,, ,, South ditto, formerly the City Canal	6	0
,, ,, Blackwall entrance	6	0
East India Docks entrance	6	6
East Country ditto ditto	5	6
Commercial ditto ditto	0	9
Grand Surrey Canal ditto	1	6

Vessels are also docked and undocked by night as well as by day; an advantage first introduced in the Port of London by this establishment.

The following Table exhibits a scale of the rise and fall of tides, and represents the depth of water upon the sills of the lock-gates at the entrance to the St. Katherine Docks, during the flood and ebb tides therein referred to.

TABLE showing the Rise and Fall of the Tides off St. Katherine Docks, with the Depths on the Sills of the outward Lock-gates. The bed of the River has been excavated in a regular slope, to the deepest part opposite the entrance, which is from fourteen to fifteen feet.

SPRING TIDES						NEAP TIDES.					
	Depth			Depth			Depth			Depth.	
	Ft.	In.		Ft.	In.		Ft.	In.		Ft.	In.
1 Hour after Flood	16		1 Hour aft High Water	21	6	1 Hour after Flood	13	6	1 Hour aft High Water	21	11
*2d do do ..	21	2	2d do do	20	10	2d do do .	16	10	2d do. do ...	18	–
3d do. do.	24		3d do. do ...	18	2	3d do. do. .	20	3	3d do do	16	2
4th do do ...	26	6	4th do. do. . ..	15	7	4th do. do ..	22	7	4th do do.. . .	15	6
5th do and at High Water	28		5th do do	13	2	5th do. and at High Water ..	24		5th. do. do	14	
			6th do do.	11	3				6th do. do	12	10
			At Low Water	10					At Low Water	12	

* Spring tides frequently lift 9 feet during the first hour flood.

The rise and fall of tides being subject to the influence of winds and weather, upon very lofty springs upwards of thirty feet depth of water exists, at times, at the entrance. The stream generally runs up from twenty-five to forty minutes after the flood tide has made its mark.

A clear water-way of not less than three hundred feet must always be kept in the Pool, according to the before-recited newly enacted Corporation by-laws of 1837; and vessels drawing twenty feet water may lie afloat at low water, secured to the principal buoy off the dock entrance. The warehouses and vaults are upon a large scale, are exceedingly well contrived and commodious, and in consequence of being built on large cast-iron columns, of the Tuscan order of Architecture, close to the water's edge, within which are the before-mentioned capacious quays, goods are housed by cranes direct from the hold of the vessel, without the necessity, as in other docks, of previously landing them on the quays: hence a great saving of room, time, labour and expense.

These docks have also a wharf between the Tower and the dock entrance, of one hundred and eighty-seven feet river frontage, for the accommodation of steam-vessels, where passengers land and embark free of expense at any time of the tide, and without the intervention of boats. Convenient waiting-rooms for passengers and their luggage are constructed, and excellent arrangements for the landing and shipping of carriages, horses, cattle &c.

The whole establishment is exceedingly complete, and is under the best regulations, printed copies of which may be had at the Dock Office. The works were designed and executed from the designs and under the superintendence of the late Thomas Telford, Esq., the first President of the Institute of Civil Engineers, and the warehouses under that of Philip Hardwick, Esq., F.R.S. &c., Architect.

In addition to the general plan of these docks, warehouses &c., Plate 4, we have also given the most authentic and correct elevations of the stupendous lock-gates and their machinery, Plate 5; a plan of the same, Plate 6; a section of the lock-walls &c., and details of the anchor for collar of the heel posts, on a large and practical scale, Plate 7; and a most accurate elevation, plan, details &c. of the cast-iron swivel bridge over the lock entrance, executed by Messrs. Seaward and Co., of the Canal Iron-works, Limehouse, Plate 8, the drawings of which were lent to the Surveyor of the Port of London by the late Mr. Telford, while the bridge was executing.

The following observations, connected with this part of our Survey, are from the pen of Captain A. G. Carlsund, a highly talented Royal Engineer, in the Swedish naval service, who died of the malignant cholera, after publishing one volume of his 'Travels in Great Britain,' and leaving another ready for the press. It is much to be wished that a good translation of this volume, from the Swedish into the English language, was published, as the author was not only a man of practical science, but an excellent observer of whatever passed his view.

In his eighth chapter he describes his voyage from London Bridge downwards, and notices the immense number and variety of the vessels which frequent our Port from every portion of the globe. He commends the build and trim of our wherries, and the skill of our watermen. The boats he calls excellent, of light construction and really beautiful appearance, which, he says, is not the case in general with the larger class of English vessels, which are seldom, if ever, of better construction than those of other nations. In going down the River he was astonished at the activity displayed on board of all the ships in the Pool, particularly those in the coal trade. He, very properly, censures the rude appearance of the shores, saying, they present a continual series of roughly-built warehouses, without symmetry, taste, or any attempt at architectural design, and consequently a wretched and ugly appearance, which seriously disappoints every foreigner, who generally arrives in London with great expectations, he says, in favour of English capital, English neatness, and English splendour. He and his companions then passed the Tower, that old fortress, he says, which is so celebrated in the history of English disturbances. Our waterman, he continues, related to us its many curiosities, and pointed out the archway through which state prisoners are conducted to their prison. He told us, that he had just before been one of the boatmen who had been employed in conveying Sir Francis Burdett from his memorable imprisonment in the Tower.

Captain Carlsund considers this ancient fortress to be a real nuisance to the Port of London, and calls its moat nothing but a receptacle for filth ; and recommends it to be pulled down, and its site converted into a large and most conveniently situated wet-dock for light shipping.

We soon arrived, he continues, at the terminus of our present excursion, the new docks, lately commenced under the superintendence and from the designs of Thomas Telford. On the space of ground called St. Katherine's, was still to be seen, in 1825, the ancient church or chapel of St. Katherine's, surrounded by a densely populated neighbourhood of labourers, sailors and publicans. A few years afterwards, he continues, I visited these spacious docks, with their extensive stacks of warehouses finished. Large ships were now floating on the very spot where, a few years previous, no other water was visible than that furnished by the water companies. On that spot, where formerly thousands of chimneys spread a thick, unwholesome smoke, we now witnessed only the smoke from a powerful steam-engine, working to maintain a proper depth of water in the docks. He describes the origin of these docks as arising from some merchants and men of property, who anticipating the great benefit that would accrue to the Port of London by the construction of docks higher up the River and nearer to the Royal Exchange than the other docks, formed a corporation or company for such purpose, and employed Mr. Telford, the most celebrated Engineer in Great Britain, to furnish them with a design suited to the situation chosen, which was between the London Docks and the Tower. The Bill met with great opposition, but was passed into an Act in 1825, and the works were began in 1826. On the site, he observes, was a church and a collegiate establishment, under the special protection of the Queen, and considered, from the most ancient times, as the property of the Queen-consort; yet, exclaims the Captain with surprise, she was obliged to consent to its removal. Before commencing the works, the strata upon which they were to be constructed were examined by boring, a method which, he says, had been lately much improved by a Mr. Good. These borings were repeated all over the site, to the depth of forty feet. The houses and other buildings were pulled down, and the ground cleared during the years 1826 and 1827 ; the excavation for the docks were began in May, 1826, and was finished within eighteen months from that time. During the progress of these extensive operations, says Captain Carlsund, I frequently witnessed a thousand men and several hundred of horses employed in the operations, besides several powerful steam-engines. At the beginning of the works wheelbarrows were employed to carry away the earth, but as the excavations proceeded and became deeper, iron railways and steam-engines were substituted. The earth was

conveyed into barges, carried down the River, and deposited in convenient places. At the first sight, he continues, the visitor was convinced that none but experienced Engineers were the conductors of the works, and such, he says, was really the case; for Mr. Logan, who, under the direction of Mr. Telford, had constructed the celebrated docks at Dundee, was here selected as the superintendent, and Mr. Rhodes, who had previously assisted Mr. Telford in the suspension-bridge over the straits of Menai, was the Resident Engineer. For the details and minute inspection of this grand undertaking, says the Captain, I feel highly obliged to those gentlemen, whose valuable acquaintance I had the pleasure of forming during my travels in 1825. The docks, of which the first stone was laid in May, 1827, were in the following October so far completed, that water was admitted from the River, and everything ready to receive ships. He then describes the docks, the buildings and the quays, with minute accuracy, and says, of the various stacks of warehouses, these colossal buildings are neither stuccoed nor painted, and are without architectural ornament, but the regularity of their enormous masses renders the whole sublime and imposing, and a decided acquisition to the improvements of the metropolis. He awards the credit of the architectural department to Mr. Hardwick, and describes the great utility of the two large steam-engines, which, besides being useful for emptying either or all of the basins, in the event of repairs being necessary, are applied to raise the water in the lock, so that vessels can be docked or undocked, during the night or day, at any time of the tide.

§ 4. The next undertaking of this nature going down the river are

THE LONDON DOCKS,

which are nearly adjoining to those of St. Katherine, and are situated in Wapping. They extend from East Smithfield to Shadwell, and were originally intended principally for the reception of ships laden with wine, brandy, tobacco and rice. These docks consist of two capacious docks; the western dock covers an area of above twenty acres, being 1260 feet long, and 960 feet wide, and the eastern dock an area of seven acres. The tobacco dock and warehouses are between them, the dock exceeding one acre in extent, and used solely by tobacco ships. The entrances to these docks are, the Hermitage or upper entrance, which leads to the western dock through the Hermitage basin, the Wapping or central entrance, which communicates with the same dock through the Wapping basin, covering an area of more than three acres, and the Shadwell or lower entrance, which communicates with the eastern dock, through the eastern basin. This lower entrance, which is of recent construction, is one mile below the Hermitage entrance, and three-quarters of a mile below the Wapping entrance. (See Plate 9.) The entire quantity of ground comprised within the outer boundary wall of the docks is seventy-one acres and three roods.

The warehouses are capacious in size, convenient in arrangement, and magnificent in design and execution. The great tobacco warehouse, on the north side of the tobacco dock, says Mr. M'Culloch, is the largest, finest and most convenient building of its sort in the world. It will contain twenty-four thousand hogsheads of tobacco, and covers the immense space of nearly five acres. There is also a very large tobacco warehouse on the north side of the tobacco dock. These warehouses are wholly under the management of the Officers of Her Majesty's Customs, the Dock Company having nothing to do with them, save only to receive the rent accruing upon the tobacco deposited in them.

Under the warehouses are a series of the most magnificent vaults in the world, and include an area of more than eighteen acres, and have convenient and ample stowage for sixty-six thousand pipes of wine and spirits.

These docks were opened on the 30th January, 1805, and the first vessel admitted was a fine brig called "*The London Packet*," from Oporto, laden with wine. All ships bound for the Thames, which were laden with wine, brandy, tobacco and rice (except ships from the East and West Indies, which use their own docks), were obliged to unload in these docks for the space of twenty-one years from the date of their opening; but this monopoly having expired January 30th, 1826, the use of these docks is optional, like the others.

The lock-gates of these docks are ingenious and scientific examples of the skill of the Engineer, and are

explained in all their details in Plates 10, 11, and 12, which are correctly engraved from large and authentic drawings made from the originals.

Of these docks our scientific Swedish traveller says, after describing them nearly as we have, but with the vivid remarks of a delighted admirer, that between the large sheds and the warehouses are series of iron railways for communication. The warehouses are built in a continued symmetrical elevation of five stories in height, strongly built of brick, and of an enormous size. He considers that although the dimensions of these docks are so very considerable, yet the regular polygonal shape of the Western Principal Dock, and its extreme width, renders it objectionable, by presenting insufficient quay room and accommodation for the number of ships which frequent them. This objection, he admits, has been partially obviated by the construction of the Eastern Basin, near Shadwell. He informs us, that the sheds and bridges are constructed on new principles, the invention of H. R. Palmer, Esq., the Engineer to the docks, and the originator of several scientific improvements in engineering, secured to him by patents. "I owe," says Captain Carlsund, "to the friendship of that Gentleman, all the details respecting these works, as well as several valuable technical instructions:" he gives us a lively and spirited account of the before-mentioned vaults, and considers them worthy the special attention of all strangers. By the light of torches, or lamps, he and his companions walked through these enormous vaults, which he compares as resembling the famous Catacombs of Rome; but he gives a preference to these of the London Docks, as containing the means of enjoying the happiness and comforts of human life.

Since the sheet containing the account of the St. Katherine Docks has been printed, the following important information has been obtained:—The chamber of the lock is sunk four feet below the level of the docks, and the waste of water during neap tides is supplied by a steam-engine of one hundred horse power, erected by Messrs. Boulton and Watt, by which a depth of water of not less than twenty-two feet is maintained in the docks. This peculiar improvement in the construction of a lock is the invention of Sir John Hall, the Secretary to the Dock Company.

§ 5. The next scientific work in the Port of London, proceeding downwards, is

THE THAMES TUNNEL,

now excavating under the River from Rotherhithe to Wapping, projected by Mark Isambard Brunel, Esq., F.R.S., and Member of the Institute of Civil Engineers. The following account is principally gathered from descriptions given under the authority of the Thames Tunnel Company.

The situation of the Tunnel is shown on the large Chart, Plate 1. On the Surrey side it opens directly into the Deptford Lower Road, a short distance from the Greenwich and Croydon Railroads, communicating with the Victualling Offices, with the Royal Dock Yards of Deptford and Woolwich, and, at the Broadway, Deptford, with the great Kent Road; also by good roads with the high roads in Surrey. On the Middlesex side it opens into Old Gravel Lane, and thence in direct communication with Ratcliff Highway, the Cannon Street Road, the Commercial Road, the proposed Railway from London to Blackwall, and the high road into Essex.

The first proposed tunnel under the Thames was from Gravesend to Tilbury, by the late Ralph Dodd, in 1799; but the scheme was soon abandoned. The next was from Rotherhithe to Limehouse, in 1804, under the authority of an Act of Parliament, projected, I believe, by the same Engineer. Another, I am informed by good authority, was projected by Captain Trevethick, near to the site of the present Tunnel, and a drift-way, after the manner of the Cornish miners, formed of about two feet wide by five feet high, quite through from one shore to the other. On the contrary, some of the oldest officers of the harbour service deny all knowledge of any such circumstance. Various other plans were subsequently proposed for the construction of the Tunnel, all of which after a time were abandoned. These proceedings are adverted to, to show the importance attached to the successful accomplishment of a roadway under the Thames.

Notwithstanding these failures, Mr. Brunel, in 1823, proposed his plan for constructing a double and

capacious roadway under the Thames; which, from the well-known talent and character of the inventor of the block cutting machinery at Portsmouth, and other original and important works of science, was immediately supported by a large body of men of wealth, rank and science, with the utmost confidence of success.

The spot selected, and as appears purposely so, is nearly the only one between London Bridge and Greenwich where such a roadway would be executed, as may be seen by the Chart, without interfering with some great mercantile or dock establishment on one side of the River or the other. Its situation is about two miles below London Bridge, in a populous and thoroughly commercial neighbourhood, where a facility of land communication is both desirable and advantageous.

While the necessary measures for obtaining an Act of Parliament were in progress, competent persons, unconnected with the Engineer, were employed by the Committee of Shareholders to take borings across the River; who reported on the 4th of April, 1824, that there was a stratum of strong blue clay of sufficient density and tenacity to insure success; and on this Report the proposed site was adopted.

The royal assent was given to the bill on the 24th of June, 1824, and Mr. Brunel appointed Engineer to the works, who began his preparations for the Rotherhithe shaft immediately. The Tunnel itself was commenced on the 3rd of March, 1825, when the Chairman, the late William Smith, Esq., M.P. for Norwich, laid the first stone, with the usual ceremonies on such occasions. On the 1st of July, 1828, the Directors reported that the works had been carried to the length of six hundred feet in a perfectly sound manner. Two irruptions of the River had previously taken place, but both had been overcome and remedied by the judicious measures adopted by Mr. Brunel.

The size of the excavation that includes the double Tunnel is thirty-eight feet wide by twenty-three feet high, and is effected by means of a powerful apparatus, which the inventor has named a shield. It consists of twelve great frames, lying close to each other, twenty-two feet high, three feet wide, and being divided into three stages or stories in height, present thirty-six cells for the workmen in this department, who are all miners, and by whom the ground is cut down and secured in front; and also for relays of bricklayers and masons who form the arches, for whom it serves as scaffolding. The first shield was placed in its proper situation, at the bottom of the Rotherhithe shaft, and completed for business, by the last day of December, 1826, and the structure of the double archway of the Tunnel was commenced under a bed of clay; but on the 25th of January following, the substantial protection of the clay was discovered to break off at once, leaving the shield for upwards of six weeks open to an influx of land-water, issuing from a bed of sand and gravel fed at each tide, and the progress of the work was in consequence much impeded. By March, this defect was remedied, the shield refixed under a bed of clay, and by the latter end of June entered under the bed of the River, a distance of one hundred and fifty feet from the shaft. In April, 1827, the Tunnel had advanced four hundred feet under the River: on the 18th of May following, and again in January, 1828, the water broke in from the River and filled the Tunnel, thereby occasioning great fears both at home and abroad, where this bold undertaking excited much interest. Mr. Brunel then had the holes in the bed of the River filled with bags of clay, and the Tunnel cleared of water, and on entering it the structure was found in a perfect and satisfactory state. The works from that time remained suspended for a period of seven years, and the public began to fear that so great an undertaking would never be resumed. They have, during the year 1836, by the zeal of the Company, and the liberality of Government, been recommenced. Another irruption, from similar causes to the former, on the 4th of November, 1837, again filled the Tunnel, but has not damped the energies of the Company and their experienced and able Engineer, for the new chasms are again now (November 29, 1837,) stopped, the Tunnel again cleared, and the works found uninjured.

The indefatigable and now experienced Board of Directors, and their undaunted Engineer, have again recommenced their works with increased energy, and every hope may be entertained that it will, ere long, be completed through to the Wapping shore, particularly as the Port of London Improvement Committee have given orders for the removal of a portion of the collier tiers of shipping from the Rotherhithe side, so as to remove temporarily the navigable channel from the part not yet excavated to

that over the completed works, which will enable Mr. Brunel to secure the bed of the River from every probable chance of injury, till the small remaining portion is completed. At that period the channel will be dredged to its original depth, and that portion of the Pool, which has been partially narrowed by the Company's tender and its works, reinstated as heretofore. We should, through the kindness of Mr. Brunel, have given further descriptions and some elucidatory engravings of every part of this extraordinary undertaking, but that gentleman had already lent his Drawings and description thereof to the Institute of Civil Engineers, of which he is a member, and they are so far engraved, and at press, that they may be expected in the forthcoming volume of the Transactions of the Institute, early in the present year.

§ 6. The next important work of skill and science in our Port, proceeding down the River, is

THE GRAND SURREY CANAL,

which, with its spacious and convenient docks, are situated at Rotherhithe, adjoining to and on the upper side of those belonging to the Commercial Dock Company.

The entrance from the Thames is between King and Queen Stairs and King's Mills, nearly opposite the lower entrance to the London Docks. The situation, plans and extent, are fully shown and described in the large Chart, Plate 1.

§ 7. Proceeding downwards in this survey, toward Blackwall, the next scientific work is

THE REGENT'S CANAL AND BASIN,

which reaches from the Thames at Limehouse to the Grand Junction Canal at Paddington. The basin is commodious and well suited to its trade, and the canal proceeds by a series of locks up the country, through Limehouse, Stepney, Hackney, Islington, the Regent's Park, and onwards to Paddington.

§ 8. The next scientific work going downwards, is

THE BROMLEY OR POPLAR CANAL,

which was made about seventy years since, from the Thames at Limehouse, where it has a capacious and secure lock for barges, through Poplar into the River Lea, at Bromley, to avoid the long and circuitous route from Bow round the Isle of Dogs to Limehouse. (See large Chart, Plate 1.) This passage is as dangerous for barges, and such other craft as navigate the Lea, as it is circuitous, and liable to constant impediments from contrary winds and tides. The entrance is between that of the Regent's Canal and Limekiln Dock, and is about one mile and a quarter in length.

§ 9. Our next step is to that magnificent establishment

THE WEST INDIA DOCKS,

which were the first wet-docks ever constructed in the Port of London. "It is singular," says Mr. M'Culloch, "that, notwithstanding the obvious utility of wet-docks, and the vast trade of the metropolis, there was no establishment of this sort on the Thames till nearly a century after a wet-dock had been constructed at Liverpool. The cause may have arisen from the lesser need of such establishments in the Port of London, from its superiority to that of Liverpool as a natural harbour, till the increased trade compelled its adoption."

These docks are not only the earliest, but are still the most extensive of the great warehousing establishments in the Port of London. They were began in February, 1800, and were partially opened in August, 1802. They are situated, as may be seen in Plates 1 and 13, across the isthmus which connects the peninsula called the Isle of Dogs with the Middlesex side of the Thames. They consisted originally of

two docks, one for imports and the other for exports, each communicating by locks, with a basin of nearly six acres in extent at the lower end next Blackwall, and with another basin of more than two acres at the upper end next Limehouse, and both communicate with the Thames by means of capacious locks and extensive pier heads.

To their already extensive premises the West India Dock Company purchased from the Corporation of London, in 1829, the City Canal, with its adjacent grounds and buildings. It runs parallel to the two other docks, is now called the South Dock, and is appropriated to the wood and timber trades, for the greater accommodation of which they have since excavated a pond of nineteen acres in extent, for the reception of bonded timber.

The Export Dock, or that appropriated for ships loading outwards, as shown in Plate 13, is about two thousand six hundred feet in length, by about four hundred feet in breadth, and covers an area of nearly twenty-five acres. The North, or Import Dock, is the same length by five hundred feet in breadth, and has a superficial area of nearly thirty acres. The north side of the Import Dock is bounded by eleven large stacks of extensive warehouses, for sugars, coffee and other dry goods; the south side by an extensive quay and warehouses for rum; and an eastern and western wood quay and sheds. The Import Dock has large sheds for the reception of goods sent down for shipment, and numerous offices for the Excise, Customs &c., and other necessary out-buildings. The whole are surrounded by lofty boundary walls; and the land side next Poplar, from the Blackwall Basin to that at Limehouse, by a broad and deep moat or ditch. Northward of the Blackwall Basin is a large elevated reservoir, and two settling reservoirs below.

The South Dock is nearly three thousand seven hundred feet in length, with excellent lock entrances at both ends, being nearly three quarters of a mile in length from pier head to pier head. Both the locks of this dock, as well as that which opens into the Blackwall Basin, are forty-five feet in width, which is wide enough to admit vessels of twelve hundred tons burthen. At spring tides the depth of water in the docks is twenty-four feet, and the whole will contain six hundred vessels, from two hundred and fifty to five hundred tons burden.

The nearest dock gate at Limehouse is about three miles from the Royal Exchange, and the other near Blackwall about half a mile more. This distance has the disadvantage of increasing the expense of cartage, and of being inconvenient to the merchants and other persons frequenting these docks; but this objection will be obviated when the railroad from London to Blackwall, which has received the sanction of Parliament, is completed. The line of this road is shown in the Chart, Plate 1.

Captain Carlsund, the scientific Swedish traveller, whose travels in Great Britain I have before quoted, extols the extreme oblong shape of these docks, as being able to accommodate a greater number of vessels than the same superficial surface of water would contain if in a different shape. Under the sheds, he informs us, are the wine cellars, which are spacious, and lighted in a manner that appeared to him as peculiar, but which are nothing more than the large spherical glasses, commonly called bulls' eyes, such as are often inserted in the decks of ships and similar places, which are fixed in the crowns of the arches, and the light diffused by large reflectors to the more distant parts of the vaults. He next describes and praises the excellent machinery used in these docks, particularly the cranes, by which a few hands can raise weights of six tons, and great saving of manual labour and time saved. Above other excellent contrivances, he particularly extols the counterbalanced platform, moved either by machinery or by the hydraulic press, and also by the direct action and pressure of water kept on purpose in reservoirs on the tops of the buildings. He also describes the wood-sheds, in which enormous quantities of mahogany, ebony, rosewood &c. are deposited, and gives due credit to the ingenious machinery of railways attached to the girders, for the use of the locomotive cranes for transporting and depositing the enormous blocks of timber, often of four and five tons weight, in their respective places, by the aid of only four or five men, which were invented and executed by the late John Rennie, who completed these docks after the death of Mr. Jessop, their prior and original engineer. He says, the sum saved in wages by this new process in the first half year, was sufficient to defray the whole expense of the machinery.

§ 10. Proceeding still downwards from the Limehouse entrance of the West India Docks, is the extensive establishment called

THE COMMERCIAL DOCKS,

the docks, yards and warehouses of which are shown with great accuracy, and to a large scale in Plate 17; and their relative situation in the Port, which is nearly opposite the upper entrance to the West India Docks, in the Chart, Plate 1. It consists of six docks, of which No. 1, formerly the Greenland Dock, covers a surface of nine acres and three quarters. The entrance to these docks is through that numbered 1, and is nearly opposite the King's Arms Public-house, Mill Wall. No. 2 adjoins the former to the westward, and covers a space of one acre and three quarters. No. 3 is northward of No. 1, to which it is connected by a cut, and contains three acres and three quarters. No. 4 is again northward of No. 3, and is similarly connected therewith, and contains ten acres. No. 5 adjoins No. 4 to the north-east, and contains fifteen acres; and No. 6 adjoins the former to the northward, and contains eighteen acres and a half. It contains several spacious bonding yards, timber sheds, warehouses, granaries, drying-kilns &c.

From the situation of these very extensive docks, which include within their boundaries nearly seventy acres, of which about fifty-eight are water, they might easily be made, now the trade of the Port of London has so wonderfully increased, and is still increasing, to be among the most prosperous establishments in the metropolitan harbour.

§ 11. Pursuing our course down the River, and passing the lower or eastern entrance of the West India Docks, the next large commercial establishment is that called

THE EAST INDIA DOCKS,

which are situated at Blackwall, three miles and a half from the Royal Exchange, as shown in the Chart, Plate 1, and to a larger scale in Plate 14. They were originally intended for the accommodation of ships belonging to or employed by the East India Company, or in that country trade; but they are now, in consequence of the dissolution of that Company as a commercial corporation, open to vessels from all parts and in all trades. They consist of an Import Dock, one thousand four hundred and ten feet in length, and five hundred and sixty in breadth, covering an area of nearly nineteen acres; and an Export Dock, seven hundred and sixty feet in length, and four hundred and sixty-three feet in breadth, covering a surface of nearly nine acres. Besides a spacious entrance basin, which connects the docks with the River, of nearly three acres. The various works of these excellent docks were executed from the designs and under the superintendence of the late Ralph Walker and John Rennie. The length of the entrance lock (see Plate 15, engraved from the original Drawings of Mr. R. Walker) is two hundred and ten feet, and the width of the gates forty-eight feet in the clear. The depth of water in the docks is never less than twenty-three feet, so that they can accommodate ships of larger burden than any other docks in the River. There is attached to these a splendid quay fronting the River, called the Brunswick Wharf, nearly seven hundred feet in length, with water sufficient at all times of the tide to float the largest steam ships; and the Export Dock is furnished with a powerful and lofty machine, which is able to mast and dismast the largest ships. This new steam-boat wharf was designed and executed with cast-iron plates and sheeting, by James Walker, Esq., President of the Institute of Civil Engineers, in the first volume of whose Transactions it is most elaborately detailed. On this wharf is the Brunswick Tavern, built for the accommodation of company arriving or departing by the larger class of steam ships, and for dinner parties in fine weather. On the upper course of the parapet of this house, over the eastern window of the bow, is marked, under the direction of the late Astronomer Royal, the true meridian from the Royal Observatory at Greenwich, as laid down in the Chart, Plate 1.

The elaborate and correct plans, sections and details of the parts at large of the entrance locks, gates and machinery, and of the coffer-dam used in forming these gigantic entrances to the East India Docks, the largest in the world, Plates 15 and 16, are all correctly reduced and engraved from the original Drawings of the late Ralph Walker, Esq.

Our before-quoted Swedish traveller, Captain Carlsund, describes these docks very carefully, and evidently from inspection. He represents our former East Indiamen as being larger than their first rate men-of-war, but from their bulky construction, being built more for stowage and commerce than for nautical manœuvring and for war, as inferior to those of our Royal Navy. He says that a portion of the commanders of these vessels were officers permitted from the Royal Navy, but many of them regularly bred in and permanently belonging to the Honourable Company's service. He inquires into all particulars like an able seaman, and says the officers and men meet with the same advancement and treatment as in the Royal Navy; and that the naval history of the United Kingdom gives many instances in which they have, with the greatest bravery, defeated many larger and more powerful French frigates and men-of-war.

§ 12. THE QUEEN'S MOORINGS AT DEPTFORD,

are introduced in this place (see Plate 18), partly to show the method of mooring by chains and anchors, and principally on account that the Harbour-masters and Surveyor, in their Report to the Select Committee of the House of Commons,* say, that from the Commercial Docks down to the middle water-gate, below Her Majesty's Dock Yard, Deptford, is occupied by Government, in which part of the River they regret not having the power to lay ships. On this head, Sir John Hall, the able and zealous Secretary to the St. Katherine Dock Company, is more explicit, saying, that additional accommodation for about sixty sail of colliers, when waiting for turns, may, without any difficulty, be found in Limehouse Reach and the vicinity of Deptford. Several of the moorings there, having been laid down for commercial purposes, and the expense paid for out of the port dues by the shipping owners, all merchant ships have a right to their use. The Queen's officer at Deptford, however, objects to any merchant vessels mooring in front of the Government yards, for which Sir John considers no justifiable ground to exist, as most of the moorings are unoccupied by Queen's ships. The Commissioner's refusal is attempted to be justified under the authority of a regulation adopted by the Lords of the Admiralty, on the 27th June, 1827, under the Act of 54 Geo. III., c. 159, which empowers the Lord High Admiral, or the Lords of the Admiralty, to make by-laws and regulations for securing access to all the royal dock yards, moorings &c. It is doubted, however, says this witness, whether the order in question has acquired the formality of a by-law. The regulation would not be objectionable, provided those moorings were actually occupied by the Queen's ships; but in the absence of such occupation, no reasonable ground can possibly exist for withholding such a valuable accommodation for the shipping which resort to our Port. If the Queen's service at any time rendered the resumption of these moorings necessary, the merchant vessels could be removed by a few hours' notice to the Harbour-masters.

This is a subject of most serious consideration in the present crowded state of our Port, and the caprice of an individual, who does not like to see merchant ships moored opposite the windows of his official residence, should not be allowed to injure the commercial business of such an harbour as that of London. It is, indeed, as Sir John Hall says, in his evidence before the Select Committee, "a question of national importance, and not, as it has been insidiously represented, one of a local character, or intended to serve partial or private interests "LONDON" being designed, to use an emphatic observation of the late and justly celebrated Mr. Pitt, "TO BE THE EMPORIUM OF THE WORLD!"

§ 13. The next step in this survey, is the CORPORATION NEW MOORING-CHAIN LIGHTER (see Plate 19), recently built, regardless of expense, by the Port of London Improvement Committee, on a larger scale and improved construction than the former one, which had been in the harbour service for nearly twenty years. The plan, section, specification &c., were drawn by the Port of London Surveyor, assisted by the practical knowledge of the experienced Superintendent of the Corporation mooring-chains. The plan and elevation are shown in the before-mentioned Plate, and the Specification for building the vessel is as follows:—

* Note *ante*, page 40.

SPECIFICATION AND DESCRIPTION

Of the several Materials to be used, and of the manner of performing the several Works required, in the Building of a new Mooring-chain Lighter, for the Service of the Honourable the Corporation of London.

DIMENSIONS.

	[illegible]	Inches
Length of the keel to tread, on the ground	40	0
Ditto aloft from the fore part of the stem to the after part of the stern-post	47	0
Ditto from bulk head to bulk head	26	6
Breadth at the fore beam	17	0
Ditto at the after beam	16	6
Midships floors to be in length	14	6
Depth from the top of the timber strake in the midships to the top of the gunwale	5	0
Free board (or outwale plank)	1	4

SCANTLINGS OF THE KEEL &c.

Keel in the midships sided thirteen inches, depth twelve inches, and to cut the rebate within eight inches of the bottom of the keel.

Stern to be thirteen inches by twelve inches, boxed or scarfed: to be bolted with four bolts.

Stern-post to be nine inches at the head, and twelve inches at the heel, and sided ten inches; and to be bolted with four bolts.

To have sufficient sound dead wood fore and aft; and to have two good grown knees of three feet and a half in each arm at least, sided to eight inches, and sixteen inches in the throat; and to be bolted with three bolts in each arm.

PLANK WITHOUT BOARD.

Plank of the bottom to be of good sound two and a half-inch elm; to have five planks at the floor heads in the midships four inches thick, and about twenty feet long, each of good sound English oak. The two upper strakes to be four-inch plank from stem to the stern-post, one foot six inches broad in midships. All the rest of outboard plank, except the above-mentioned plank of the bottom, to be of good sound two and a half-inch English oak. All the plank to be of good length, with six feet shift at least.

SCANTLINGS OF THE TIMBERS.

The floor timbers to be of good sound English oak, free from large vents, shakes and sap, and not fox-coloured; twelve inches broad, and eleven inches deep, at least, at the cutting down line in the midships, and to be eight inches moulded at the head.

Every floor timber afore or abaft the ends of the keelson to be bolted through the keel and dead wood, and to be clenched.

The keelson to be six inches thick and thirteen inches wide, fore and aft, and to reach from dead wood to dead wood; to be bolted through every floor timber and heel that it rests on, and the bolts to be one inch diameter, and clenched.

To have an apron to the stem, sided seventeen inches, and one to the stern-post, sided fifteen inches.

Lower futtocks to be grown timber, sided to seven inches, and seven feet in length, and to be moulded at heads seven inches.

Top timbers or upper futtocks to be sided seven inches, and moulded at the heads four inches and three quarters.

BEAMS.

The fore and after beams to be sided twelve inches square. Each beam to have four lodging knees; the lodging knees to be fifteen inches in the throat, and sided seven inches. The arms to be three feet six inches long, bolted with six bolts. To have a small beam eight inches by six inches, to reach athwart from side to side, to support the fore deck, to be eleven feet six inches.

To have sufficient strong ledge-combings to the fore and stern deck, and a scuttle or hatch to the stern deck. Plank of the fore and stern decks to be three inch oak, and to be well caulked.

The fore deck to have four leaden scuppers, two to the beam, and two through the bows. The after deck to have two lead scuppers next the beam.

To have a small beam eight inches by six inches, to reach athwart from side to side, to support the stern deck abaft the hatch.

The fore and stern decks to camber at least five inches; from the top of the ore deck to the top of the gunwale twelve inches; from the top of the stern deck to the top of the gunwale twelve inches.

To have two hooks in the fore and two in the stern sheets, twelve inches in the throat, and sided seven inches, of good length, with two eakings to each hook to reach the bulkhead, bolted with six bolts in each.

To have a sheer hook forward, and one aft, the height of the gunwale, sided seven inches, and bolted with seven bolts.

To have four bollards, two forward and two abaft, ten inches by eight inches, to ship and unship, to stand above the gunwale twelve inches, and to run down to the futtock timbers.

The windlass chocks to be fitted to the side timbers, six feet long and eighteen inches broad, ten inches thick, joggled to the side timbers three inches at the least, and bolted with sufficient bolts.

The windlass to be of the full length between the chocks. The body to be twenty inches, of good sound African oak, to be whelped with two-inch English oak, and Baltic fir plank alternately. To have six handspike holes, three on each side, where directed. To have two pall bits, ten inches square, to step on the floor timber, and bolted to the after beam. Windlass to have two iron patent palls fixed. The windlass to be hooped with four strong iron hoops, three inches broad and three quarters of an inch thick; to have an iron spindle at each end two inches and a quarter in diameter, turned and case-hardened; to work in well-fitted wrought-iron square boxes, to be fitted into the ends of the windlass, and properly bolted. To have an iron hoop two inches and a half broad by three quarters of an inch thick on the top of the stern-post. The davit to stand six feet six inches beyond the stem head, to fix on a step on the keelson inside the fore sheets. To have two* sheaves at the head of the davit, and to be finished in every other respect, except the number of sheaves, as the davit of the present lighter, difference of dimensions alone excepted. The fore and aft bulk heads to be provided and fitted similar to the present lighter, allowing for the difference of dimensions.

PLANK WITHIN BOARD.

The clamp and flat of the floor, from keelson to floor heads, to be of three-inch oak plank, and the rest of the side ceiling to be of two inches and a half oak, up to within four inches of the inwales. The inwales

* The former lighter had only one sheaf

or top plank to be of oak four inches thick. The fittings under the fore and aft decks to be as in the present vessel, allowing for difference in dimensions.

The gunwale to be four-inch oak plank from stem to stern.

Bolster planks and bolsters in bows to be put on after the vessel is finished, in a similar manner and of similar dimensions as those in the present vessel, allowing for difference in size.

All the timbers to be treenailed with good dry-seasoned treenails, and where it can be done the treenails to be driven from the outside, to be wedged from the inside. All the timber and plank and treenails to be oak of English growth, free from sap, rot or shakes; no pollard timber to be used; all the sap to be sawn off.

IRON WORK.

The iron work about the bows and stern to be provided and fitted in a similar manner and of similar dimensions to the present lighter, allowing for difference of size. To have two iron breast-hooks, one forward and one aft, under the sheet hooks, to reach from the stern forwards and the stern-post aft to the bulk head of each, four inches broad, three inches in the throat, and three quarters of an inch thick, bolted and clenched to each timber.

The lighter to have good sheer fore and aft, and to be well caulked and pitched without side. To provide and fix all other necessary iron work and materials whatsoever, as well not mentioned as mentioned, sufficient and convenient for the hull of a chain lighter, that the Corporation may be at no expense for extras, except what may be beyond the fittings and finishings of the present chain lighter, difference of dimensions alone excepted.

All the before-mentioned works are to be done in the most sound and workmanlike manner, and with the best materials of their several sorts, to the satisfaction and under the superintendence of Mr. James Elmes, the Surveyor of the Port of London, and Mr. Matthew Marshall, Superintendent of Mooring-Chains in the said Port, or of any other Surveyor of the Port of London, or Superintendent of Mooring-Chains, for the time being, whom the Worshipful Committee for improving the Port of London may please to appoint, who are to be at liberty to order any defective or bad materials or workmanship to be removed, and redone at the expense of the Contractor. Notice in writing to be given to the said Surveyor of the Port of London and Superintendent of Mooring-Chains, both before and when the keel is laid, and when the stem and stern-posts are up, and the frame knees are in and ready for planking; and also when the lighter is planked up to the top of the side, and when finished (before she is tarred, payed or launched), in order for their inspection and survey. The whole to be performed, finished and completed as before-mentioned, and to be launched and delivered safe afloat in the River Thames, by the 1st of June next, under the penalty of two hundred pounds, and to be built under a dry shed or workshop.

§ 14. The various modes of mooring vessels in the Port of London, and the various details of mooring-chains, links, swivels, shackles, mooring-stones, Mitchell's patent screw-moorings and the mode of affixing them, are shown in Plates 20 and 22; in the latter of which the screw-moorings, and the mode of laying them down in the River, are shown. In the upper part of Plate 20 are the plans of a mooring-chain, which generally consists of eighteen links, one swivel in the centre, and a shackle at each end to connect them with other mooring-chains if needful. The iron of which these mooring-chains &c. are made, will perhaps be better explained by extracts from the Specification of the last Contract, and from the Drawings after which the Engravings are made. "The proposals are to specify in writing, in words at length, the price per hundred weight for fifty pieces of mooring-chain of eighteen links each, with a swivel in the centre of each piece, each link to be two inches in diameter in round iron, and twelve inches in the clear. Also fifty shackles, with bolts, rings and forelocks complete, two inches in diameter in round iron, and twelve inches in the clear."

"The whole of the chains and shackles are to be made of the best and toughest faggoted Swedish iron,

or nut or scrap iron, and to be manufactured in the most sound and workmanlike manner, and to be subject to such test* or trial as to toughness and strength, as shall be considered necessary by the Surveyor of the Port of London for the time being. If any of the links, swivels or shackles should be found defective or deficient, either in quality of materials or workmanship, they are to be replaced at the Contractor's expense by others, subject to similar test, trial and approbation. The Contract was taken by tender in the two last instances by Messrs. John Duffus, James Forbes, George Forbes, Alexander Bannerman, John Lumsden, George Elmslie the Younger, and William Reid, of Aberdeen, and of High Street, Wapping, iron merchants, who have executed them in that excellent manner which such important works require, whether the value of the ships and cargoes which are held at their mercy, or of the human life on board of them, be taken into consideration. The links, swivels and shackles are shown in Plate 20, the former to a larger scale.'

Below the preceding are shown the manner in which the harbour service of the Port of London lay down the large mooring-anchors in the stream, in such deep water as at Northfleet-hope &c., and the manner of laying down mooring-stones and chains in the Pool. The latter represents the new large chain lighter, with a mooring-stone, and a mooring or bridle-chain attached to the lighter's heaving-chain. Below is the hole excavated for its reception, considerably deeper than the thickness of the stone, which is lowered into the hole under the direction of the Superintendent of Mooring-Chains, which, when lowered and ascertained to be level by sounding staves and observations thereon by the marking of the tides, ballast is then thrown thereon, and the whole levelled to an equality with the bed of the River, as shown in the diagram immediately adjoining the aperture; so that if a ship were to ground over any of our mooring-stones, no injury could accrue to her, as the whole body of the stone and iron work, except the bridle-chains, therein shown as lying on the bed of the River, and out of use, are completely under the bed of the River. The ends of these bridle-chains are often kept on the surface of the water by buoys, for the occasional and temporary mooring of vessels. The cost of making these holes for the stones, which are of necessity excavated and filled in by the Trinity Corporation (see ante, page 22, § 5), are as follows, taken indiscriminately from a Trinity House bill for the year ending December 31, 1836, namely, for one stone."

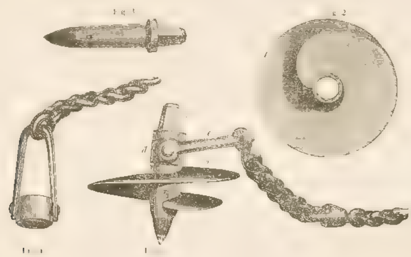
1836.				
March 3rd	To seven tides, making hole for the outside mooring-stone off Church Stairs, Rotherhithe, per Lighter No. 8, at one pound eleven shillings and sixpence per tide	£11	0	6
,,	To one hundred and thirty tons of Ballast laid on ditto, at one shilling and three-pence per ton	8	2	6
,,	To three nights Watching, at five shillings per night	0	15	0
	Total for one hole	£19	18	0

The description of the mooring-stones may also be best furnished from the Specification and Description made for the Contractors. "The Contractor is, at his own cost and charge, to find and provide twelve mooring-stones for the harbour service of the Port of London of the following dimensions, viz., six feet long, five feet wide, three feet thick, and not to weigh less than five tons and a half each stone." These mooring-stones have stood the test of experience nearly half a century; and, after much investigation into many others, as of granite, composition, iron &c., the principal officers of the harbour service have come to the conclusion, that neither in material nor in size can they be improved for their harbour. The Surveyor, however, thinks, that if they were made of larger dimensions at the bottom than at the top, or, as technically called, dovetailed, on the principle of the Lewis-iron, it would be an improvement. The adhesive, porous and hardening quality of the roche or cap Portland Stone, becomes in time a part and parcel, as it were, of the bed of the River, and they are, consequently, very seldom drawn away from their berths by the largest tiers of shipping in the most boisterous gales that have been known in the Port.

Among many proposed improved moorings that have been recently submitted to the Port of London Improvement Committee, none have received so much attention from that body as the Patent Screw

* The test usually adopted in the harbour service, is first by the chain cable hydraulic testing machine, under a certificate of the strain to which they are subjected, and then by smiths, who strike the links &c. in the presence of the Surveyor and Superintendent with heavy hammers, wherever ordered, and particularly at the shuts or junctions

Moorings, invented by Mr. Alexander Mitchell, of Belfast, ten of which have been inserted into the bed of the River in the Pool by order of the Committee, under the direction of the Patentee, his son and the Superintendent of the Mooring-Chains. This description of mooring is constructed, as its name implies, on the principle of the screw (see Plate 22, and the following wood-cut),



but differing somewhat in form from that well-known mechanical power, its thread taking but little more than one turn round its shaft, extending to a very broad flange. This flange, when forced round by means of a long shaft, adapted by joints to the depth of water, as shown in Plate 22, is insinuated into the bed of the River until a firm hold is obtained, when the long shaft is withdrawn, leaving the mooring at the required depth, with a strong bridle-chain attached. Figure 1 shows the screw mooring as prepared for use; *a* is a spiral or screw flange of about one turn and a half, having a hollow cylindrical centre, as shown in Figure 2, and of cast-iron in one piece; *b* is a wrought-iron spindle, which passes through the cylindrical socket of the screw flange, somewhat tapering in form, as shown in Figure 3, and, when driven up tight, is fixed thereto by a forelock, which passes through both; it is formed with a square head, *c*, to receive the key for screwing it into the ground; *d* is a collar of wrought-iron, the front of which is shown in Figure 4, fitted so as to turn freely on the upper part of the shaft of the spindle below the collar. Figure 2 shows the upper surface of the spiral flange; Figure 3 the spindle; and Figure 4 the collar and shackle. The shackle is fixed to the spindle by means of the loose collar, in order to prevent the dragging round and the consequent fouling of the chain whilst the spindle is being turned in or out of the ground.

§ 15. In Plate 21, I have given a section of the River from London Bridge to Bugsby's Hole, with soundings at every quarter of a mile, surveyed and taken by me in 1835, and compared with those taken by the Harbour-masters at various times, and by George Rennie, Esq., F.R.S. To accompany which the following observations on the course, dimensions, inclinations and velocities of the River Thames, and the effects which have been occasioned by the removal of the old and the building of the new London Bridge, are added. They are taken from a series of experiments and observations made on the River by Messrs. George and (Sir) John Rennie, during the years 1832, 1833 and 1834, communicated to and published in the Report of the Fourth Meeting of the British Association for the Advancement of Science, held at Edinburgh in 1834, by George Rennie, Esq., F.R.S., &c. &c.

From these excellent observations and Report are deduced that the general course of the Thames is from west to east. Like other rivers, it forms the drainage of a very extensive district, by means of rivulets and streams, which conduct the waters of the uplands into one great artery or trunk, and conveys them to the sea. The total number of these affluents may be about twenty.

It is difficult to estimate the superficial extent of country drained by the River Thames, but the authors of these observations estimate it as being at the least five thousand square miles. The course of the River is very tortuous and winding, particularly between Deptford and Blackwall, and is double its length, circuitously, of its distance from its source to its mouth, measured by a straight line.

The navigable distance from London to Lechlade is about one hundred and forty-six miles and a half;

but from Sheerness the total distance is two hundred and four miles and a half. The total fall of the River, from Lechlade to low-water mark, is two hundred and fifty-eight feet, or twenty-one inches per mile; and this fall is nearly uniform, although there are places where the fall varies from nineteen inches to thirty-two inches per mile, as shown in the following Table, calculated by those Gentlemen, who observe, that in no instance is the funicular curve of M. Gerard established.

RIVERS ISIS AND THAMES.

NAMES OF PLACES.	LENGTH.		FALL.		FALL IN FEET PER MILE.	RATIO OF INCLINATION.
	Miles.	Furl.	Feet.	Inches.		
From St. John's Bridge at Lechlade, to Folly Bridge at Oxford	28	0	47	0	1·68	$\frac{1}{3143}$
„ Oxford to Abingdon Bridge	9	0	13	11	1·73	$\frac{1}{3052}$
„ Abingdon to Wallingford Bridge	14	0	27	4	1·95	$\frac{1}{2708}$
„ Wallingford to Reading Bridge	18	6	24	1	1·31	$\frac{1}{4030}$
„ Reading to Henley Bridge	9	0	19	3	2·14	$\frac{1}{2467}$
„ Henley to Marlow Bridge	9	0	12	2	1·35	$\frac{1}{3911}$
„ Marlow to Maidenhead Bridge	8	0	15	1	1·86	$\frac{1}{2839}$
„ Maidenhead to Windsor Bridge	7	0	13	6	1·93	$\frac{1}{2737}$
„ Windsor to Staines Bridge	8	0	15	8	1·96	$\frac{1}{2694}$
„ Staines to Chertsey Bridge	4	6	6	6	1·44	$\frac{1}{3667}$
„ Chertsey to Teddington Lock	13	6	19	8	1·45	$\frac{1}{3641}$
„ Teddington Lock to London Bridge	19	0	2	9	145	$\frac{1}{37413}$
„ London Bridge to Yantlet Creek	40	0	2	1	052	$\frac{1}{101537}$
„ Lechlade to Yantlet Creek	185	0	218	0		
Deduct from London Bridge to Yantlet Creek	40	0				
From Lechlade to London Bridge	145	0				

"The velocity of the Thames might be expected," says Mr. George Rennie, "to follow the law of variation of the inclinations; but that the natural obstructions which exist in all parts of the river upwards, from bends, shoals, islands, weeds &c., and the artificial obstacles from weirs, pound-locks, fishing ayts &c., render it impossible to ascertain the velocity correctly. Much depends also upon the volume of water passing down the river, and the use of *flashes*."

In general the velocity may be estimated at from half a mile to two miles and three-quarters per hour; but the mean velocity may be reckoned at two miles per hour. In the year 1794, the late Mr. Rennie found the velocity of the Thames at Windsor two miles and a half per hour.

Previous to the erection of the old London Bridge in the year 1209, there can be no doubt that the state of the River was very different from what it is now, and that many of the lowlands which are now embanked out, were formerly covered both by the floods and the tides. "The old bridge," says Mr. Rennie, "although it obstructed the flood of the tides to their full heights, operated reversely with the land-waters, by penning them back; and in extreme cases the difference of level was found to be occasionally as much as fourteen inches between the high-water below and above bridge, and five feet seven inches between low-water mark above and below bridge, depending of course on the state of the freshes and the tides. The bridge was considered to act like a pound-lock, and by penning up the water, to tranquillize the motion of the current and to deepen the navigation above. In consequence, however, of the danger and inconvenience arising from both the impeded navigation through the bridge and the floods, Mr. George Dance was instructed by the Corporation of London, to whom he was architect and surveyor, in the year 1746, to draw up a series of queries, which were addressed to the Royal Society."

The result was a Report from that Society, requesting certain information relative to the tides, which, however, did not elicit anything positive upon the subject until the year 1754, when the erection of Blackfriars Bridge was contemplated. The opinions of Mr. Robertson, as detailed in Dr. Hutton's

mathematical tracts, were given on the unfounded supposition, that the proposed bridge was to have been built with piers and starlings like old London Bridge, and to have produced a similar obstruction. The enlargement of the waterway by Mr. Dance, in 1759, by lowering the surface of the water several inches, caused a diminution both in the depth of the water and in the power of the water-works. The area of the waterway was again contracted, and the River restored to its former state, on the supposition that the navigation would have been otherwise injured, and the lowlands overflowed. And when the question of rebuilding the bridge came to be agitated, it was argued that the old bridge acted as a bar, to check the velocity of the River both ways; that an increased velocity in the River would impede rather than accelerate the navigation, as wherries and small craft would not be able to stem the current; that the bed of the River would be laid dry during the ebb tide; and lastly, that the upper part of the River would be choked with mud, and that all the low grounds on either side of the River would revert to marshes, and become uninhabitable.

On the other hand it was contended, that the tide would not rise more than a few inches higher than formerly, or fall lower than three feet; that the old bridge not only acted as a dam to check the flux and reflux of the tides, but also tended to pen back the land-waters, and to cause floods above; and that the proof of the bridge causing such an effect, was the greater prevalence of floods before the enlargement of the waterway of the old bridge, in 1759, than afterwards; that the decrease in the velocity of the River tended to assist the filling up and raising the bed by depositions of gravel and mud; that independently of the annual loss of lives and property, as returned by the Corporation, and printed in the Report of the Select Committee of the House of Lords on old London Bridge, in 1820, occasioned by the contracted waterways of the bridge, the navigation of the River was at times wholly impeded; whereas by removing the dam, the great increase in the velocity of the current would clear the bed of the River, facilitate its navigation, and effect a more perfect drainage of the country, by the quicker passing off of the land-floods; that the River being more perfectly emptied at each reflux of the tide, the flux would have less time to fill the increased void; and that, therefore, before the tide had obtained its greatest surface of elevation, it would have began to run down; that although many shoals would have undoubtedly been exposed at low-water, yet the increased velocity of the current, assisted by dredging the hard places, would very soon reduce the channel to its ancient depth. The latter assertions have been verified to their full extent, as will be hereinafter shown.

The phenomena of the tides in the Port of London have been very ably discussed by John William Lubbock, Esq., Vice President of the Royal Society, and by the Rev. Professor Whewell, in the *Philosophical Transactions* for the years 1831, 1833 and 1834. The former Gentleman in his papers, which contain numerous tables, compiled from 13,073 observations made at the London Docks, in a period of nineteen years, that is, from January 1, 1808, to December 31, 1826, with the corrections for the time of high-water, as it is affected by the right ascensions, declinations and parallaxes of the sun and moon; and the latter in his paper on the empirical laws of the tides in the Port of London, and in his essay towards a first approximation to a map of co-tidal lines.

To both of these Gentlemen, and also to Mr. George Rennie, the author of this work is under great obligations, and has drawn largely on their very scientific reports and experiments in this portion of his survey.

Sir John Hall, the active and intelligent Secretary of the St. Katherine Dock Company, has given the following information relative to the influence of the wind upon the tides in the Port of London to Mr. Lubbock, who has thought it of sufficient importance to print in his communication to the Royal Society in 1834. Sir John Hall procured the joint opinion of some nautical men, including Captain Compton, the Dock-master of St. Katherine Docks, and Captain John Fisher, R.N., the Superintending Harbour-master of the Port. The following is the result of their sentiments respecting the influence of the wind upon the tides in the Port of London.

During strong north-westerly gales, the tide marks high-water earlier than otherwise, and does not give so much water, whilst the ebb-tide runs out later, and marks lower; but upon the gales abating, and the

weather moderating, the tides put in and rise much higher, whilst they also run longer before high-water is marked, and with greater velocity of current; nor do they run out so long or so low. The reason assigned for this is, that the strong north-west winds drive the sea along the Dutch coast, through the Straits of Dover, and, consequently, away from the mouth of the Thames; so that the tides, during north-west winds, are always much higher on the Dutch coast, producing frequently ruinous flooding thereto, than upon the English coast. A south-westerly gale has generally a contrary effect, and an easterly wind gives some water; but the tides, in all these cases, always improve the moment the weather moderates.

This is the opinion of those Gentlemen who are most competent to form one, from their daily experience, and, in Mr. Lubbock's opinion, is doubtlessly correct. The subject is one of considerable importance, as regards the accuracy of which tidal predictions are susceptible, and merits further inquiry, in order to ascertain, if possible, the error which may be expected for a wind of given force and direction.

"In the case of the times of high-water especially," says Mr. Whewell, "the general course of the variations of the quantities is as regular as can be expected, and is as requisite for his formulæ. The *heights* are much more anomalous: probably they are more affected by winds &c. than the *times* are; and, when it is considered that the tide at London may be affected by the operation of causes in a remote part of the ocean, propagating their effect by the progression of the tide-wave, there need not be any surprise at considerable deviation from the rule. The trade-winds, and other winds of the tropical regions, may be felt in our tides, and may even affect the means of long series of observations; for it is to be recollected, that the averages which we obtain are not the averages of the effects of the sun and moon only, but the averages of their effects, together with that of meteorological causes."

"It is, moreover, to be observed," he continues, "that the peculiar circumstances of the Port of London, in having a tide compounded of two tides arriving by different roads, after journeys of different lengths, may easily be supposed to give rise to additional chances of irregularity." Concerning these causes of inaccuracy in tidal observations, Professor Whewell says—

"There is a fact, no doubt, that most all the statements of such discrepancies are founded in a mistake, arising from the comparisons of two different phenomena, namely, *the time of high-water*, and the time of the change *from the flow to the ebb current*. In some cases the one, and in some the other of these times has been observed as the *time of the tide*; and in this manner have arisen such anomalies as have been mentioned.

"The time of the change of current, or the *time of slack water*, never coincides with the *time of high-water*, except close in upon the shore, and within its influence; the interval of the two times is generally considerable. Great confusion has been produced by these two times not being properly distinguished; so great, indeed, that almost all the tide observations which we possess are of doubtful value."

"The persuasion that in waters affected by tides the water rises while it runs one way, and falls while it runs the other, though wholly erroneous, is very general."

Pursuing the subject in relation to the Port of London, Mr. G. Rennie observes—"That in the River Thames the motion of the current continues for some time after the tide has made its mark, which is undoubtedly owing to its momentum. In general, the tides of the River Thames have been found to observe considerable regularity, both in their elevations and periodical times, except when influenced by winds and floods. In comparing, however, the sea tide with the river tides, a considerable discrepancy is found to prevail in the elevations; in some cases, on account of the convergence or swelling of the tidal wave, on the principle of the conservation of mechanical force, as in the Severn &c.; and in other cases a lowering of the surface by expansion, as in the Mersey, which is very narrow at its mouth."

Many surveys have been made of the River Thames, and observations on the tides in the Port of London, from the time of those made by Mr. H. Saumarez, and published in the 'Philosophical Transactions for 1720,' down to those made under the directions of the late Mr. Rennie, by order of the Lords

Commissioners of the Admiralty, and of the Corporation of London, and also by the late Mr. Telford, previous to the building of London Bridge; but no measures were adopted to ascertain the effect which the removal of the old bridge has had upon the operations of the tides, till those made by Messrs. Rennie for that purpose.

On the new bridge being opened, on the 1st of August, 1831, the demolition and removal of the old bridge commenced on the 22nd of November following; and on the 25th, Mr. Combe (Messrs. Rennies' Assistant) was instructed by those Gentlemen to proceed up the River to collect information, and to make a series of observations at Putney, Kew and Richmond Bridges, and at Teddington Lock. Tide gauges accurately adjusted by levelling to a tide gauge, similarly fixed at new London Bridge, at Fresh Wharf and a little below the bridge, were fixed at those places, and experienced persons were appointed to keep a daily register of the high and low-water marks as indicated by the gauges. The observations commenced on the 1st of December, and were continued till the 1st of June, 1832; at which period no more than two piers which obstructed the waterway had been removed. These removals, however, had lessened the fall at low-water nearly one foot.

In 1833, almost all the masonry and starlings were removed, and the whole finally in 1834, and the results of these useful observations are, that from the substitution of the new for the old London Bridge, the drainage of the districts bordering on the Thames, as well as the navigation of the River, has been greatly improved; that barges, which used formerly to be towed up from Putney to Richmond by horses, are now carried from London Bridge to Richmond in one tide; that the fall of the low-water surface *below* bridge has been so considerable, as to cause ships in many instances to ground in their tiers at low-water; and that from a register of tides kept by Captain Maugham, of the London Docks, the average depth at low-water on the sill of the Shadwell Dock was one foot ten inches below the old Trinity datum; and that where there were formerly eight feet in depth upon the Dock sill, there were then only six feet two inches on the average. On the 5th of November, 1834, the tide fell as low as four feet three inches on the sill.

The very valuable observations of the late and present Messrs. Rennies, Telford, Giles, Professor Whewell and the highly and important tables of Mr. Lubbock, compiled from upwards of ten thousand observations, have contributed very largely to our knowledge on the subject of the tides of the Port of London. Of these latter tables, indeed of all the papers contributed by Mr. Lubbock and Professor Whewell to the Royal Society, it is much to be desired that they were collected into one convenient volume for greater public utility than they are at present.

§ 16. Plate 22 is principally occupied by diagrams of various methods of mooring ships in the collier Pool, according to the Corporation by-laws. They are arranged for a tier of twenty ships, ten moored with their heads up the stream, and ten with their heads down the stream; moored by their heads, secured together by their sterns, and boomed off to make room for lighters and coal barges to be loaded or unloaded between them. The first eight ships, A A, are moored, four with their heads up the stream, and four with their heads down, to the mooring-stones and bridles delineated in Plate 20. Eight more, B B, are similarly secured by bridle-chains from Mitchell's patent screw-moorings, as recently fixed down in Mill Hole tier; and four others, similarly placed, but moored by their own anchors.

Before closing this subject, a few observations are requisite on the necessity of removing all the shoals that at present obstruct the navigation of large ships in the Port of London. Captain Bullock, one of the nautical surveyors of the Royal Navy, says, in his Evidence before the Select Committee, in June, 1836, that they are pointed out to him on the Plans* before him; that "the whole Pool is excavated into holes and hills; the Upper Pool is full of shoals, and the Lower Pool but little better." Deputy Tickner, who was four years a member and two years chairman of the Port Committee, in 1832 and 1833, informed the same Committee, when asked about the shoals, that "the Surveyor of the Port of London reports upon this subject to the Committee, and that it is a matter of very serious importance. The Committee having

* Those before mentioned, that were made by order of the Port of London Improvement Committee.

no funds at their disposal for such purposes, have therefore been constrained to have recourse to the Elder Brethren of the Trinity House to do that, there being a doubt, as the law exists, whether the tonnage duty can be legally appropriated to the removal of shoals in the Port of London; and I think it is very desirable that Parliament should clear away that doubt, and make those duties applicable to such highly desirable purposes."

Mr. Tickner considered also, that nothing could be more equitable than that the tonnage duties should be applied to the removal of the shoals; that he had made many applications to the Trinity Board with respect to their removal, and that the answer he generally received was, "that unless the shoals consisted of materials that could be available for ballast, they could not help us." Hence the hills and holes of which Captain Bullock, and every other scientific person acquainted with our Port, complain. He considered also, that the means for removing obstructions, and for improving the navigation of the Port, ought to be provided for out of the tonnage duties; that there was a surplus at that time (and is now) which could not be better appropriated than by removing the shoals, and otherwise improving the Port.

Just before the completion of this work, Mr. Weale, its public-spirited publisher, sent me a very curious book, in the form of a letter to the Earl of Marlborough, giving "An account of several new inventions and improvements now (1690) necessary for England, relating to the building of our English shipping, planting of oaken timber in the forests, apportioning of public taxes, *the conservancy* of all our royal rivers, in particular that of the *Thames*, the surveys of the *Thames* &c. By Thomas Hale. London, 1691." Among other inventions he calls his patron's attention to one which he calls *incomparable*—"the new engine that so much excels all formerly used for the eternal preservation of our royal rivers, by deepening them and making them everywhere navigable, and taking away all obstructions and shelves in a very short time. Sir Martin Beckman, the Chief Engineer of England, and, as I am informed, Sir Christopher Wren, their Majesties' Surveyor-General, have given their approbation thereof; and as likewise did King Charles II., who was highly pleased therewith, and declared, after he had seen the working of the engine, which in His Majesty's presence took up about a ton and a half in little more than a minute's time, that he was perfectly satisfied it would answer the end proposed; and that by means of its working *horizontally*, it made no holes, but rather filled such as lay in the way of its working, and left the bottom of the River level as it wrought, whereby such inconveniences would be avoided as had happened from the common ballast lighters making such great holes in the River of Thames, and in which several of the King's as well as merchant ships coming to an anchor had broke their backs." So we find complaints of holes and of ballast lighters not so very modern.

"And His Majesty having been made acquainted that this engine, being sent down to Berkingshelfe, where there is nothing but hard shingle, and that after half an hour's breaking ground it took up, at nineteen feet deep, about two tons in a minute and a half during the whole time it wrought, he said thereupon, that there was no way practicable for the deepening of the River Thames, and removing shelves therein, but by this engine. This engine (he says) was invented by Mr. Bayley, an excellent engineer, and much cultivated and improved to its present perfection by the great expense of Mr. Joseph Cotinge. King Charles II., so often going down the River in his barges and yachts, took occasion thereby often to consider the state thereof, insomuch, that upon a public hearing in Council that the Lord Mayor and Aldermen had upon their complaints against patents that straightened the River, and licensed encroachments on it, he took occasion to speak it openly, that the River was shallower before his Yard at Deptford by three feet since his restoration, and that if it should be but a foot shallower, his ships that did ride at anchor there would be spoiled."

Farther on he says: "I remember visiting my worthy friend, Mr. Brisband, who was Secretary to the former Lords Commissioners for the Admiralty; he entertained me with the sight of many papers in his office that related to the applications that had been made by the City of London to that Board, for the preservation of the River of Thames; and one of them was a paper of the City's reasons against the patents for licensing encroachments and straightening that River, and which seemed to me very weighty, and drawn up with such great care and pains, that what chancellor soever drew them, I am sure he deserved a very

large fee from the City, and out of which I noted down this passage, namely: *That if that River were spoiled, the great trade of England would be transplanted, not to other sea-ports in England, but to foreign parts.* Mr. Brisband also informed me, that those Commissioners of the Admiralty, as well as the Lord Mayor, had taken a great deal of pains in the preserving of the River, and that it was incumbent on both their offices so to do; for which purpose he showed me a most judicious and learned Report, made by the Judge of the Admiralty, wherein it was said that the Admiral is by his office and patent not only *Custos maritimarum partium*, but *Custos portuum et Conservator fluminum infra fluxum et refluxum maris;* and that he is by his patent empowered to make sub-conservators, and hath by the statute *primo Elizabethæ*, a concurrency with the Lord Mayor of London in the Conservatorship of the River of Thames."

After several pages of interesting matter on the subject of our Port and River, he says, "There is one thing that hath caused most horrible ill effects to this River, and I have met with no man who hath observed it, and therefore it is fit it should be known, and that is, the fire of London. For every five yards of pavement a load of gravel is used, and a great part of this gravel lies so loose, that by force of the rain it is frequently driven into the sewers and the Thames; and every pavement raiseth the street paved two inches at least; but the burned part of London is at a medium four feet higher. And so I account, that by the fire and rebuilding of London, more gravel and soil hath gone into the Thames, than perhaps will again in the next three hundred years."

His observations on the tides of the Thames are so curious and valuable, and so confirmatory of every recorded observation on them, from Flamstead downwards, that I cannot help quoting them, although I have much exceeded the limits which I had prescribed to myself when I began this work. They are as follow:—"Since I have been, as I may say, a student of this River, I have taken occasion to pity those who look on the strange shifting of tides in this River as a great prodigy, because happening seldom. But I think the cause of the shifting of the tides is only the overbearing of their course, when they are at their slackest, by a north-west wind, which is the most powerful adversary they can have on our coasts; for if a slow ebb be encountered full in the teeth with a hard storm, what can follow but a return of the tide back again? And if the north-west wind either abates its fierceness, or shift into some other quarters, as the south-west or north-east, for some short time, and then either return to its former place or resume its former force, and do this once, twice and again, which we know is not inconsistent with the nature and custom of the wind off at sea, though at land its wanderings are not altogether so sensible, we may easily believe, seeing so plain a reason for it, that there will be a playing of the tide to and fro, and several floods and ebbs succeeding one another in a few hours' space."

The succeeding observations are replete with sound sense and worthy of present observation. "And here I shall take occasion to observe, that it is not only possible in some cases to take in some part of the River without prejudice to it, but it is also probable that the taking in some places of the River would tend to the good of it. The general rule is, that we may with safety *gain* upon the hollow shore, but not on the convex shore, or where there are head-lands, for then it would change the channel and turn the stream into eddies; as for example, if the Custom-House Quay should be carried further, which is already brought to the channel, it would be fatally mischievous."

The following is also curious, as combining singular matters of fact with antiquarian literature. "It hath been told me by several skilful surveyors, that after the fire of London, upon digging the foundations for the present Custom-House, they found that it was all such as we call *made-earth*, and had been gained out of the Thames. Therefore it was, I account, with great prudence, that the conservators of the River consented that, till they came to deep water, it should be gained in for the better convenience of navigation, that vessels might float at ebb, as they now do at the Custom-House. The same Surveyors assured me, that under St. Magnus Church, they, after the fire, met with an old campshot and wharfing gained from the Thames, and at the same time, they informed me that they found campshots much farther from the Thames in digging of cellars; and whence it may be inferred, probably, that all Thames Street, downward to the Custom-House, was gained out of the Thames."

The next quotation is singularly valuable, as it may lead to the recovery of these ancient surveys. He

informs us, after previously mentioning it in the future tense as hereafter to be done, that "there were, by the appointment of King Charles II., two surveys made of the River Thames, the one of the several depths of the River in its parts below bridge, performed with much care and skill by that excellent mathematical person Sir Jonas Moor, and a copy of which I can direct the conservators of the River where to obtain for an inconsiderable charge. The other was a survey of encroachments, performed by the Navy Board and the Trinity House, with the assistance of Captain Collins, His Majesty's hydrographer, and wherein I said great pains were taken; and a copy whereof is herewith published for the use of the conservators of the River, and I can direct them to Captain Collins's most accurate draught of the River, and most necessary to be had by them;—and he, in my judgment, deserves to be well rewarded with some acknowledgment by the City for the great pains taken, and skill by him shown in that draught, tending to the preservation of their River. For he hath thereby laid an everlasting foundation for the easy and certain prevention of all future encroachments on the Thames, and which may be this way, and I believe cannot be possibly effected by any other—namely, of the Lords Commissioners for executing the office of the Lord High Admiral shall appoint the Marshall of the Admiralty, or some other person, and the Lord Mayor appoint his Water-bailiff or Surveyor at the mending or repairing of any wharf upon the Thames, to see a stake stuck down, beyond which the repairers of the wharf shall not proceed; and both these officers shall be ordered to demolish immediately whatever shall have been added beyond such stake. Captain Collins's draught doth sufficiently set forth how far the encroachments were made before the month of October, 1684, the month in or about which he gave in his draught, and to which this printed survey refers."

"Upon my consulting the authors that wrote of the Regalia, to know their sense of the office of a conservator, I found this definition of it there, viz.—'*Conservator est qui sine judiciale examine jus aliquot publicum tuetur.*' Nor is there any moot-point in our law that need divert our conservators of the royal River from the immediate demolishing of nuisances, *sine judiciali examine.*"

He also acquaints us, that Charles II. had been long acquainted with the doctrines of nuisances—that he considered a patent for a nuisance as not being worth its weight in burnt silk—and that he had often been heard to say, in reference to the encroachments in the Port, that "he would damn all patents that dammed his River."

§ 17. The last section in this work is a statistical account of the steam navigation of the Port of London, and of the steam-vessels belonging to and frequenting that Port. The increase of all commercial business in our Port has been of late quite extraordinary, as may be seen in the following Tables, extracted from the Parliamentary Report of August, 1836. In the year 1830, the number and tonnage of all the vessels that frequented the Port were as follows:—Those engaged in the foreign trade, 361 ships, equal to 73,634 tons, and 185 coasting ditto, equal to 48,100 tons; making together 546 ships and 121,734 tons. In 1835, the vessels in the foreign trade, 1076 ships and 266,684 tons; those in the coasting trade, 699 ships and 448,424 tons of shipping; which gives an increase over 1830 of 326,690 tons, which is equal to 371 per cent. The increase in the number of steam-boats is equally surprising. In 1820, there were only four steam-packets; in 1830, twenty; in 1835, forty-three. The still farther increase is to be seen in the following statistical accounts of the steam navigation of our Port.

Before quitting this subject, I feel strongly impelled to quote the following remarks as to the steamers, given before the Parliamentary Committee in August, 1836, and to refer my readers to my Report to the Committee, printed in the same Report, on the best mode of improving the Port of London, which has been declared excellent, but too costly. The observations are by Sir John Hall, and every unprejudiced person must admit their truth, and the necessity of their adoption:—"It is worthy of notice, that such steam-boats are exempt from the Port dues, and do not, therefore, contribute to the expense of maintaining the mooring in the Port, or of the harbour service, although they make use of the moorings, and thus occupy a portion of accommodation, provided at the expense, and to the exclusion, of all other classes of shipping."

STEAM VESSELS that Arrive and Sail to and from the Port of London, corrected up to July, 1837.

COASTERS.

NAMES.	WHERE RUNNING.	PLACE OF DELIVERY.	NAMES.	WHERE RUNNING.	PLACE OF DELIVERY.
City of Aberdeen	Aberdeen	Iron Gate Wharf.	Ipswich	Ipswich.	St. Katherine's Wharf.
Queen of Scotland	ditto.	ditto.	Courier	ditto.	ditto.
Duke of Wellington	ditto.	ditto	Royal William	Leith.	ditto.
Lee	Cork.	Alderman's Tier.	Royal Adelaide	ditto.	ditto.
Emerald	ditto.	ditto.	Princess Victoria	ditto.	ditto.
Hercules	ditto.	ditto.	Caledonia	Edinburgh.	Brunswick Wharf, Blackwall.
Herald	ditto	ditto.	Monarch	ditto.	ditto.
Eclipse	Dartmouth	Cotton's Wharf, Tooley St.	Leith	ditto.	ditto.
Dover Castle	Dover.	St. Katherine's Wharf.	Clarence	ditto.	ditto.
Water Witch	ditto.	ditto.	London Merchant	ditto.	ditto
Thames	Dublin.	East Lane.	Magnet	Margate.	London Bridge Wharf.
Shannon	ditto.	ditto.	Albion	ditto.	ditto.
William Fawcett	ditto.	ditto	Dart	ditto.	ditto.
City of Londonderry	ditto.	ditto.	Venus	ditto.	ditto.
Royal William	ditto.	Davis's Wharf.	Fame	ditto.	ditto.
William Penn	ditto.	ditto.	Royal William	ditto.	ditto.
Perth	Dundee.	Hoare's Wharf, Wapping.	Royal Adelaide	ditto.	ditto.
Dundee	ditto.	ditto.	Royal George	ditto.	ditto.
London	ditto.	ditto.	City of London	Ramsgate.	ditto.
Cornubia	Exeter	Alderman's Tier.	Princess Victoria	Sheerness.	ditto.
Zephyr	ditto.	ditto.	Prince George	ditto.	ditto.
Essex	Gravesend.	London Bridge Wharf.	Duke of Sussex	ditto.	ditto.
Diamond	ditto.	ditto.	Majestic	Stockton.	ditto.
Pearl	ditto.	ditto.	Nora Creina	Waterford.	East Lane.
Brabant	ditto.	ditto.	St. Patrick	ditto.	Davis's Wharf.
Kent	ditto.	ditto.	Margaret	ditto.	ditto.
Gem	ditto.	ditto.	Waterford	ditto.	Jeffery Smith's Wharf.
Mercury	ditto.	ditto.	Clonmell	ditto.	ditto.
Planet	ditto.	ditto.	Kilkenny	ditto.	ditto.
Star	ditto.	ditto.	Scotia	Boston.	Uncertain.
Comet	ditto.	ditto.	Naiad	Woolwich.	Hungerford Stairs.
Medway	ditto	ditto.	Fairy	ditto.	ditto.
Gem	ditto	ditto.	Sylph	ditto.	ditto.
Vesper	ditto.	ditto.	Nymph	ditto.	ditto.
Dolphin	ditto.	Hungerford.	Falcon	ditto.	London Bridge Wharf.
Rose	ditto.	Nicholson's Wharf.	Eagle	ditto	ditto.
Ruby	ditto.	ditto.	William the Fourth	Whitstable.	Dyer's-hall Wharf.
Royal Tar	Greenwich.	London Bridge Wharf.	Duchess of Sutherland	Inverness.	Downes' Wharf.
Greenwich	ditto.	ditto.	Montrose	Montrose.	ditto.
Greenwich	ditto.	ditto.	City of Edinburgh	Newcastle.	ditto.
Nelson	ditto.	Dyer's-hall Wharf, Ths. St.	Prince Frederick	Hull.	ditto.
Victory	ditto.	ditto.	James Watt	Stockton.	ditto.
Hardy	ditto.	ditto.	Ormerod	Liverpool.	ditto.
Nile	ditto.	ditto.	Fly	Richmond.	ditto
City of Canterbury	Herne Bay.	London Bridge Wharf.	Diana	ditto.	ditto.
Red Rover	ditto.	ditto.	Goole	Hull.	ditto.
Yorkshireman	Hull	Wool Quay.	Endeavour	Richmond.	ditto.
Gazelle	ditto.	ditto.	Severn	ditto.	ditto.
Water Witch	ditto.	St. Katherine's Wharf.	Leeds	ditto.	ditto.
Vivid	ditto.	ditto.	City of Limerick	Limerick.	ditto.
Enterprise	ditto.	Wool Quay.	Emerald Isle	Liverpool.	ditto.
Monarch	ditto.	ditto.	Braganza	Dublin.	ditto.
William Wilberforce	ditto.	St. Katherine's Wharf.	Paris	ditto	ditto.

FOREIGN.

NAMES.	WHERE RUNNING.	PLACE OF DELIVERY.	NAMES.	WHERE RUNNING.	PLACE OF DELIVERY.
Tourist	Antwerp.	Upper Pool.	Ramona	Rotterdam.	Custom House.
Attwood	ditto.	ditto.	Sir Edward Banks	ditto.	ditto.
Princess Victoria	ditto.	ditto.	Batavia	ditto.	East Lane.
Soho	ditto.	ditto.	Queen Adelaide	Havre.	Iron Gate Stairs.
Harlequin	Boulogne.	London Bridge Wharf.	John Wood	ditto.	ditto.
Brockelbank	ditto.	ditto.	Clyde	ditto.	ditto.
Royal Sovereign	ditto.	ditto	James Watt	Lisbon.	ditto.
Emerald	ditto.	ditto.	Liverpool	Uncertain.	Uncertain.
Apollo	ditto.	ditto.	Belfast	ditto.	ditto.
William Jolliffe	Calais.	Tower.	Brockelbank	ditto.	ditto.
Lord Melville	ditto.	ditto.	Qn. of the Netherlands	ditto.	ditto.
Calpe	Lisbon.	East Lane.	Kg. of the Netherlands	ditto	ditto.
Transit	ditto.	ditto.	Superb	Belfast.	ditto.
Essex	ditto	ditto.	Hylton Jolliffe	Uncertain.	ditto.
Liverpool	ditto.	ditto.	Tourist	ditto.	ditto.
Glasgow	ditto.	ditto.	Mountaineer	ditto.	ditto.
Manchester	ditto.	ditto.	Talbot	ditto.	ditto.
Don Juan	ditto.	ditto	Rapid	ditto.	ditto.
Tagus	ditto.	ditto.	Waterloo	ditto.	ditto.
Braganza	ditto.	ditto.	Lord of the Isles	ditto.	ditto.
Iberia	ditto.	ditto.	Ocean	ditto.	ditto
John Bull	Hamburgh.	Custom House.	Giraffe	ditto.	ditto.
City of Hamburgh	ditto.	ditto.	Countess Lonsdale	ditto.	ditto.
Britannia	ditto.	ditto.	Neptune	ditto.	ditto.
Columbine	ditto.	ditto.	North Star	ditto.	ditto.
Earl Liverpool	Ostend.	ditto			

MALCOLM DUNNETT, Jun., Clerk to the Harbour-Masters

AN ACCOUNT of the Number of Steam-Vessels belonging to the Port of London, corrected up to 22nd November, 1837, by the Registrar-General of Shipping, Custom-House, London.

JOHN COVEY, Registrar-General of Shipping.

NAME OF VESSEL.	WHERE AND WHEN BUILT.	LENGTH.		BREADTH.		DEPTH.		REGISTER TONNAGE.	PLACES WITH WHICH THE VESSELS USUALLY TRADE.
		Ft.	In.	Ft.	In.	Ft.	In.		
Enterprize	Lond[illegible], [illegible]825	141	6	27	8	5	11	275 [illegible]	East Indies.
Emulous	[illegible], 1825	125	3	19	5	9	9	[illegible]	Ditto.
Sir Joseph Yorke	Chester, 182[illegible]	84	8	16	4	7	3	$61\frac{64}{94}$	Chester.
Malvina	Inverness, 1824.	58	0	[illegible]	9	5	11	58 [illegible]	Towing.
Enterprize	London, 1826.	14[illegible]	[illegible]	26	6	1[illegible]	0	[illegible]	East Indies.
D[illegible] M[illegible]d	Chester, 1827.	77	0	16	1	8	0	[illegible]	Chester.
Endeavour	London, 1827.	7[illegible]	6	19	0	7	2	3[illegible]	Richmond.
Mercury	ditto, 1826.	120	8	17	1	6	6	108 [illegible]	Mediterranean
Fly	ditto, 1830.	86	0	13	10	6	6	53 [illegible]	Gravesend.
[illegible]	ditto, 1826.	[illegible]4	6	10	6	6	1	13 [illegible]	Towing.
Sophia Jane	ditto, 1826.	1[illegible]0	3	20	1	10	5	$153\frac{77}{94}$	Laid up.
D[illegible]	ditto, 1831.	98	0	12	6	6	8	[illegible]	Richmond.
[illegible]	ditto, 1820.	91	0	19	3	6	8	$51\frac{56}{94}$	Ditto.
[illegible]	ditto, 1825.	108	0	20	0	9	1	1[illegible]5 [illegible]	Antwerp.
[illegible]	ditto, 1821.	113	0	18	6	10	7	$118\frac{43}{94}$	Rotterdam.
Pearl	ditto, 1829.	103	0	17	6	9	4	$94\frac{6}{94}$	Jam[illegible]
Eclipse	Greenock, 1821.	104	0	16	9	9	2	87 [illegible]	Dart[illegible]
[illegible]	ditto, 1820.	94	0	17	3	9	0	$88\frac{86}{94}$	Unknown.
Rose	London, 1832.	100	0	15	6	8	11	$73\frac{9}{94}$	Sheerness.
Swift[illegible]	ditto, 1821.	10[illegible]	0	16	5	8	9	88 [illegible]	Greenwich.
William Joliffe	ditto, 1826.	115	0	22	5	13	5	23[illegible]	Calais.
Revolution	ditto, 1832	[illegible]	6	7	2	3	10	7 [illegible]	Experimentally.
Cape Breton	ditto, 1833.	1[illegible]4	6	20	8	9	8	$124\frac{47}{94}$	Cape Breton.
John and Richard	Newcastle, 1832.	51	11	12	8	6	6	18 [illegible]	Towing.
M[illegible]	London, 1828.	40	7	8	3	4	9	5 [illegible]	Experimentally
Royal William	Quebec, 1831.	160	0	28	0	6	2	[illegible]63 [illegible]	Unknown.
Hawk	London, 1826.	107	6	17	5	9	[illegible]	$104\frac{14}{94}$	Suc[illegible]ess
Aerolite	Cowes, 1833.	55	9	8	11½	3	5	11 [illegible]	Experimentally.
Waterloo	Greenock, 1819.	1[illegible]0	0	21	3	[illegible]	6	12[illegible]	Antwerp
Columbine	London, 1826.	157	6	24	5	13	9	24[illegible]	Rotterdam
King of the Netherlands	ditto, 1822.	1[illegible]9	9	19	3	8	3	$134\frac{40}{94}$	Newcastle.
United Kingdom	Greenock, 1826.	17[illegible]	9	26	5	16	3	$335\frac{23}{94}$	Unknown.
Brilliant	London, 1832.	[illegible]9	0	20	6	10	10	$180\frac{37}{94}$	Gravesend
Fly	ditto, 1833.	54	3	8	2	2	7	$13\frac{6}{94}$	Experimentally
Star	ditto, 1832.	40	0	7	3	2	2	5 [illegible]	Ditto.
Sylph	ditto, 1834.	100	5	11	8	7	[illegible]	50 [illegible]	Woolwich
Queen Adelaide	ditto, 1828.	[illegible]	3	8	10	6	5	19 [illegible]	Towing.
Nelson	Newcastle, 1834.	83	4	18	7	8	8	$58\frac{42}{94}$	Greenwich.
Tam O'Shanter	ditto, 1834.	76	0	15	6	9	0	$40\frac{27}{94}$	Ditto.
Jardine	Aberdeen, 1835.	81	9	17	1	9	5	58 [illegible]	Unknown.
Diamond	London, 1834.	111	9	18	2	8	6	$159\frac{86}{94}$	Gravesend
Wear	Sunderland, 1825.	67	7	16	0	9	4	35 [illegible]	Towing
I[illegible]	Newcastle, 1827.	63	0	1[illegible]	0	7	0	27 [illegible]	Ditto.
Levant	London, 1835.	68	0	15	0	10	3	$64\frac{5}{94}$	Levant.
Kingston	Gainsborough, 1829.	78	5	19	0	7	10	69 [illegible]	Towing.
Greenwich	London, 1835.	122	3	1[illegible]	1	7	10	$95\frac{70}{94}$	Greenwich.
Royal Tar	ditto, 1835.	109	8	15	[illegible]	7	5½	[illegible]	Ditto.
Beaver	ditto, 1835.	101	4	20	0	11	0½	109 [illegible]	Hudson's Bay.
N[illegible]	ditto, 1835.	[illegible]06	10	14	6¼	7	8	$76\frac{47}{94}$	Woolwich.
[illegible]	ditto, 1835.	[illegible]06	6	14	8	7	9	$77\frac{13}{94}$	Ditto.
Vestal	ditto, 1835.	13[illegible]	[illegible]	21	0	13	0	$173\frac{53}{94}$	By Trinity Company.
Dolphin	ditto, 1834.	12[illegible]	5	15	6	8	4	$105\frac{44}{94}$	Gravesend.
Pearl	ditto, 1835.	140	7	17	4½	8	4	1[illegible]	Ditto.
Britannia	ditto, 1835.	160	9	26	1	1[illegible]	4	320 [illegible]	Hamburgh.
Robert and Henry	Newcastle, 1835.	[illegible]6	7	11	7	7	0	$23\frac{17}{94}$	Towing
Comet	London, 1834.	158	0	18	6½	9	8	157 [illegible]	Gravesend.
Medway	ditto, 1834.	12[illegible]	5	20	1	10	7	$168\frac{70}{94}$	Ditto.
Pilot	Newcastle, 1830.	57	0	12	7	7	8		Experimentally.
Vera Paz	Newcastle, 1835.	[illegible]3	4	17	10	8	5	87 [illegible]	Vera Paz.
Star	London, 1834.	151	4	21	0	8	9	$226\frac{85}{94}$	Gravesend.
Mercury	ditto, 1834.	143	6	21	0	10	7	202 [illegible]	Ditto.
P[illegible]	ditto, 1835.	153	8	18	6½	10	5	184 [illegible]	Ditto.
Essex	ditto, 1829.	122	0	18	4	9	11	1[illegible]	Ditto.
Jarrow	Newcastle, 1831.	58	6	13	7	8	3	$21\frac{41}{94}$	Towing.
Monarch	ditto, 1833.	64	10	13	1[illegible]	7	0	$26\frac{29}{94}$	Ditto.
James Watt	Liverpool, 1824.	1[illegible]	3	[illegible]9	0	11	7	$141\frac{75}{94}$	Spain.
Con[illegible]	[illegible], 182[illegible].	11[illegible]	0	17	5	8	2	[illegible]02 [illegible]	Yarmouth.
William Symington	ditto, 1835.	79	10	15	8[illegible]	7	7	42 [illegible]	Towing.
J[illegible]	Newcastle, 1826.	[illegible]9	1	11	5	6	6	15 [illegible]	Ditto.
Sir Robert Hanks	ditto, 1835.	76	4	1[illegible]	2	8	6	44 [illegible]	Ditto.
Clyde	Greenock, 1831.	1[illegible]3	2	20	7	14	0	$195\frac{82}{94}$	Havre.
Water Witch	Chepstow, 1834.	73	6	15	5	6	9	$26\frac{75}{94}$	Towing.
Chieftain	Greenock, 1825.	115	6	24	4	13	9	26[illegible]	Hamburgh.

THE UNDERMENTIONED VESSELS ARE ADMEASURED UNDER THE ACT 5 AND 6 WM. IV

NAME OF VESSEL	WHERE AND WHEN BUILT	LENGTH	BREADTH	DEPTH	REGISTER TONNAGE	PLACES WITH WHICH THE VESSELS USUALLY TRADE
		Ft. Tenths	Ft. Tenths	Ft. Tenths		
Transit	London, 1835.	126 0	19 6	13 0	160	Lis[illegible]
Vesta	ditto, 1835.	126 [illegible]	16 6	9 9	[illegible]	Unknown
City of Canterbury	ditto, 1835.	156 0	21 0	10 2	154 [illegible]	Herne Bay
Red Rover	ditto, 1835.	145 6	21 4	10 0	[illegible]	Ditto.
Princess Victoria	ditto, 1835.	113 2	16 7	11 3	[illegible]	Sheerness.
Emerald	ditto, 1834.	143 6	20 0	12 5	178 [illegible]	Boulogne
Novelty	ditto, 1835.	102 0	1[illegible] 2	8 0	47 [illegible]	Holland.
Gipsey	ditto, 1836.	119 6	15 6	7 8	81 [illegible]	Greenwich.
Water Lily	ditto, 1836.	120 0	15 7	7 8	84 [illegible]	Ditto.
Eclipse	ditto, 1829.	125 3	16 9	10 3	111	Dartmouth.
City of Hamburgh	ditto, 1834.	160 5	23 8	15 9	353	Hamburgh.
John Bull	ditto, 1835.	164 9	25 8	17 2	345	Ditto.
Gem	ditto, 1836.	152 4	18 7	9 5	102 $\frac{8}{10}$	Gravesend.
London Merchant	ditto, 1831.	154 5	[illegible]	15 1	187 $\frac{4}{10}$	Hamburgh.
Harlequin	ditto, 1826.	138 1	22 4	12 6	185 $\frac{1}{10}$	Boulogne.
Tourist	Perth, 1821.	136 0	20 4	12 3	1[illegible]2	Antwerp.
Caledonia	London, 1836.	178 0	26 9	17 7	425	Hamburgh.
Sir Edward Banks	ditto, 1826.	122 0	19 6	13 8	151 [illegible]	Ditto.
Ramona	ditto, 1828.	148 8	22 0	13 7	177 [illegible]	Rotterdam
Queen Adelaide	Glasgow, 1830.	127 2	21 9	13 6	173 $\frac{7}{10}$	Havre.
Attwood	London, 1825.	147 0	19 8	14 0	189 $\frac{7}{10}$	Rotterdam.
Hero	Rochester, 1821.	133 0	20 2	12 0	150	Gravesend
City of London	London, 1824.	126 0	19 0	11 3	104 $\frac{4}{10}$	Ramsgate.
Royal Sovereign	ditto, 1822.	135 3	19 2	12 0	102 [illegible]	Ditto.
Majestic	Greenock, 1821.	134 2	21 0	12 6	143 [illegible]	Isle of Wight.
Prince George	London, 1826.	136 6	16 8	9 [illegible]	89 $\frac{7}{10}$	Boulogne.
Kent	ditto, 1829.	125 0	17 4	10 5	103 [illegible]	Ditto.
Lady de Saumarez	ditto, 1835.	127 2	20 0	12 8½	148 $\frac{613}{3300}$	Hamburgh.
Mo[illegible]	ditto, 1833.	184 3	[illegible]	17 6	[illegible]	Leith.
Menai	Port Glasgow, 1830.	128 5	18 9	12 2	136	Ditto.
Venus	London, 1821.	12[illegible] 5	21 1	11 0	185	Gravesend
Lord Melville	Chester, 1822.	124 0	19 [illegible]	12 3	116	Ostend.
Dartford	London, 1836.	126 4	18 3	11 9	12[illegible]	Dartford.
Soho	ditto, 1823.	1[illegible]0 5	[illegible]7 8	17 3	292	Antwerp
Belfast	Belfast, 1820.	114 7	18 2	12 2	109 $\frac{7}{10}$	Calais.
Giraffe	London, 1836.	142 0	[illegible] 8	14 6	2[illegible]	Rotterdam
Duchess of Kent	ditto, 1836.	155 5	20 4	11 0	11[illegible]	Boulogne
John Wood	Port Glasgow, 1831.	132 7	22 6½	14 0	180 $\frac{14}{64}$	Havre.
Ocean	London, 1836.	1[illegible] 0	[illegible] 9	14 9	201 [illegible]	Antwerp.
Harriet	Liverpool, 1836.	89 0	14 8	7 9	4[illegible]	Unknown.
Dart	London, 1825.	129 7	20 3	11 6	1[illegible]5	Margate.
Iona	ditto, 1836.	124 6	19 0	13 3	105 $\frac{9}{10}$	Ionian Islands.
Iberia	ditto, 1836.	55 4	21 2	15 7	301 $\frac{9}{10}$	Lisbon.
Margaret	ditto, 1826	139 1	21 2	12 5	166	Ramsgate.
[illegible]	ditto, 1836.	67 0	13 6	9 0	28 [illegible]	Towing.
Kent	Newcastle, 1835.	56 8	12 8	6 8	15 [illegible]	Ditto.
Clarence	London, 1836.	178 0	27 0	[illegible]	426	Leith.
London	Newcastle, 1836.	84 5	15 5	9 0	41 [illegible]	Towing.
Albion	London, 1823.	131 8	20 8	10 8	166	Ramsgate.
Souter Johnny	Newcastle, 1836.	82 7	15 8	9 4	36 [illegible]	Towing.
Atalanta	London, 1836.	170 0	25 1	18 7	389 $\frac{7}{10}$	Cape of Good Hope.
City of Glasgow	Greenock, 1832.	119 6	20 5	11 2	124	Boulogne.
Countess of Lonsdale	London, 1836.	174 0	24 7	17 4	397 [illegible]	Hamburgh.
Fame	ditto, 1834.	150 1	21 2	11 6	172	Ramsgate
Hercules	Newcastle, 1836.	87 0	16 8	10 4	90 $\frac{4}{10}$	Unknown
Neptune	London, 1837.	171 3	[illegible] 8	17 1	386 $\frac{7}{10}$	Hamburgh.
City of Kingston	ditto, 1837.	133 0	20 7	14 1	22[illegible]	Jamaica.
Leith	Leith, 1837.	181 0	26 8	16 4	464 [illegible]	Leith.
Ruby	London, 1837.	151 10	18 7	10 5	132 [illegible]	Gravesend.
F[illegible]	Newcastle, 1834.	64 6	12 8	7 6	2[illegible]	Towing.
Samson	ditto, 1837	81 0	15 9	9 1	34	Ditto.
Hardy	London, 1836.	1[illegible] 7	14 3	8 0	54	Greenwich.
Nile	ditto, 1837.	106 5	[illegible] 7	7 6	68	Ditto.
Victory	ditto, 1837.	106 0	14 8	8 0	68	Ditto.
Nelson	ditto, 1836.	102 6	14 5	8 0	51	Ditto
Minerva	ditto, 1837	72 4	10 7	4 9	20	Towing.
[illegible]	ditto, 1835.	[illegible]	19 5	12 8	157	Lisbon
Apollo	Glasgow, 1832	127 8	14 3	9 1	97 [illegible]	Ditto.
Water Lily	London, 1828.	[illegible] 8	12 2	6 5	[illegible]5 [illegible]	Towing
Sir Lionel Smith	Bristol, 1837.	114 6	18 0	11 4	130 $\frac{8}{10}$	Jamaica.
Dragon	London, 1837.	88 7	17 0	9 5	39 $\frac{4}{10}$	Towing.
Topaz	ditto, 1837.	134 0	[illegible]	7 9	83 [illegible]	Gravesend.
Earl of Liverpool	ditto, 1823.	128 0	19 6	14 2	11[illegible]	Ostend.
City of Edinburgh	ditto, 1821.	134 6	[illegible]	14 0	25[illegible]	Leith
Hercules	Gravesend, 1837.	94 2	16 5	9 8	53 [illegible]	Lanelly
Newcastle	Newcastle, 1824.	86 0	14 6	6 8	41 $\frac{6}{10}$	Towing.
William the Fourth	London, 1830.	114 4	14 7	9 0	[illegible]	New South Wales.
James Watt	Port Glasgow, 1821	145 0	25 6	16 8	290 [illegible]	Leith.
Duke of Sussex	London, 1835.	143 8	16 4	9 8	104 $\frac{7}{10}$	Boulogne.

Since the preceding sheets went to press, the following important communication, relative to the still increasing commerce of the Port of London over the gratifying statement in pages 32 and 33, was laid before the St. Katherine Dock Company by their Chairman, Thomas Tooke, Esq., at the Annual Meeting of Proprietors, on Wednesday, the 16th of January, 1838 :—

Ships with Cargoes that entered the Port of London from Foreign Parts during the Years 1836 *and* 1837.

	BRITISH.		FOREIGN			TOTAL	
	Vessels.	Tons.	Vessels.	Tons.		Vessels.	Tons.
1836	3,500	766,010	1,449	249,080		4,949	1,015,090
1837	4,058	818,179	1,530	236,662		5,588	1,054,841
Increase	558	52,169	81	12,418 Less tonnage	Total increase	639	39,751

Coasting Trade with London.

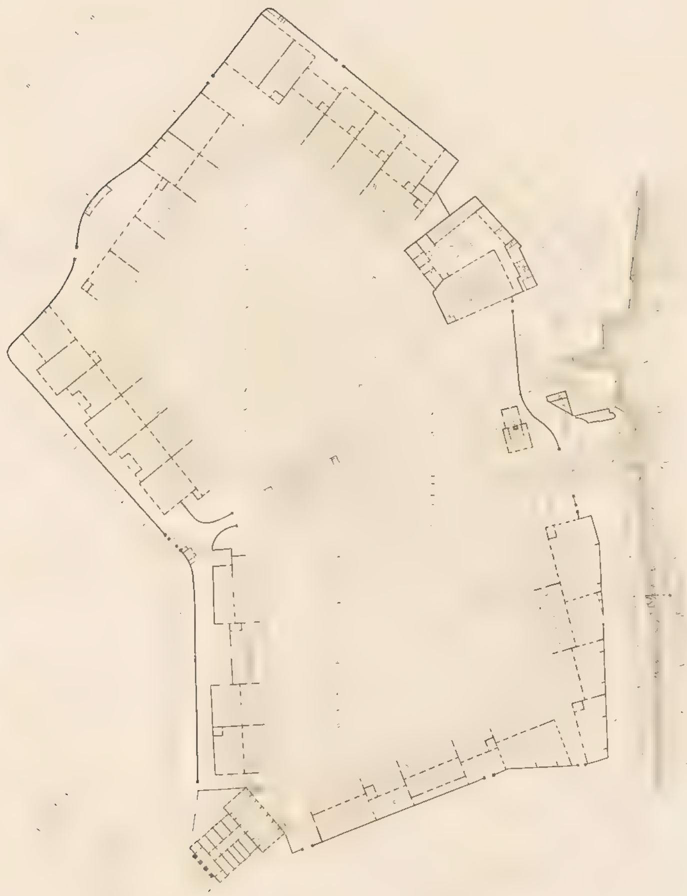
	BRITISH	
	Vessels.	Tons.
1836	19,715	2,656,750
1837	21,320	2,811,520

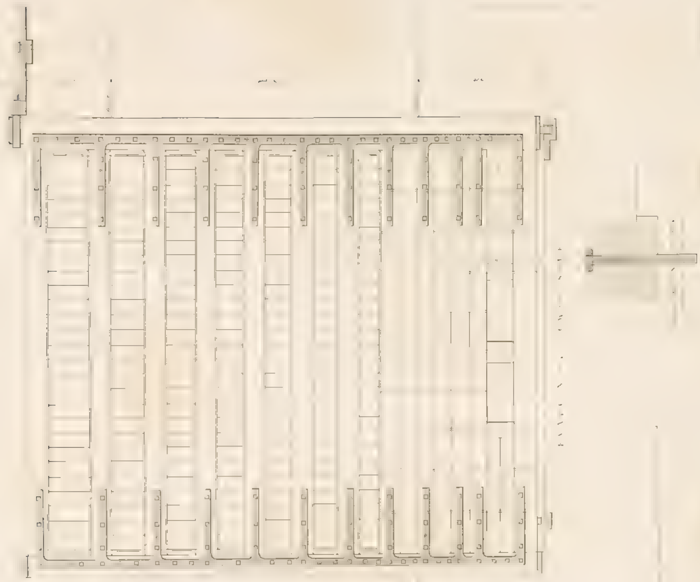
	Vessels.	Tons.
Increase over 1836	1,605	154,770
Add increase in Foreign Trade	639	39,751
Total increase	2,244	194,521

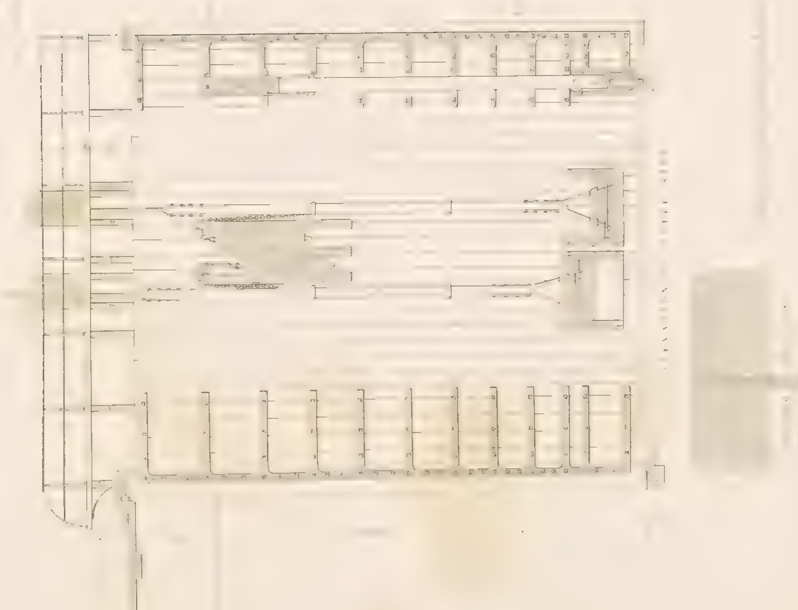
The aggregate tonnage of British ships that entered the Port of London in 1837, amounted to no less than 3,629,699 register tons, which exceeds considerably in amount any previous year in its history, and affords additional reasons, if any were required, for extending the accommodation of the Port for Colliers, and for the removal of the shoals and other obstructions to the navigation, as before alluded to in pages 22, 24, and 25.

THE END

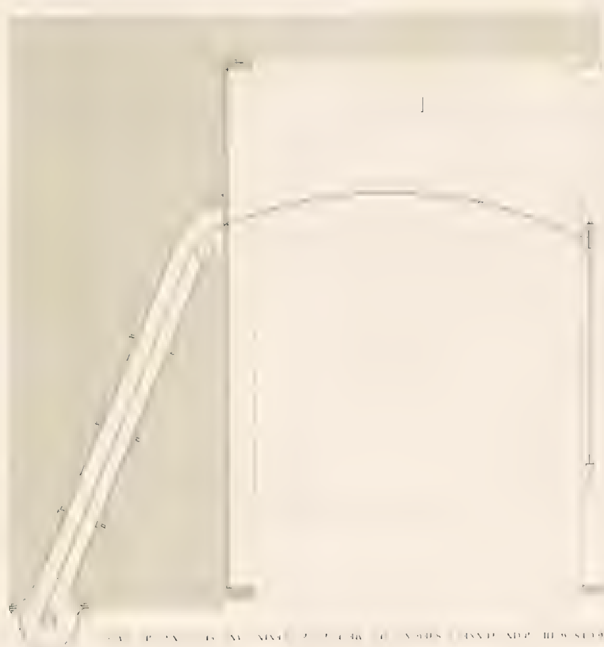
[illegible] PRINTERS, CRANE COURT, FLEET STREET

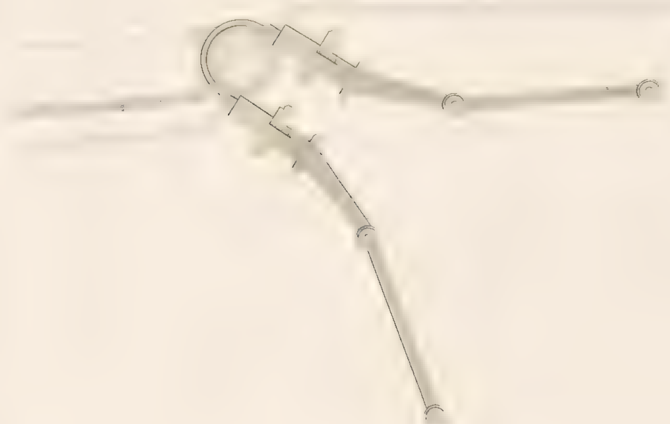


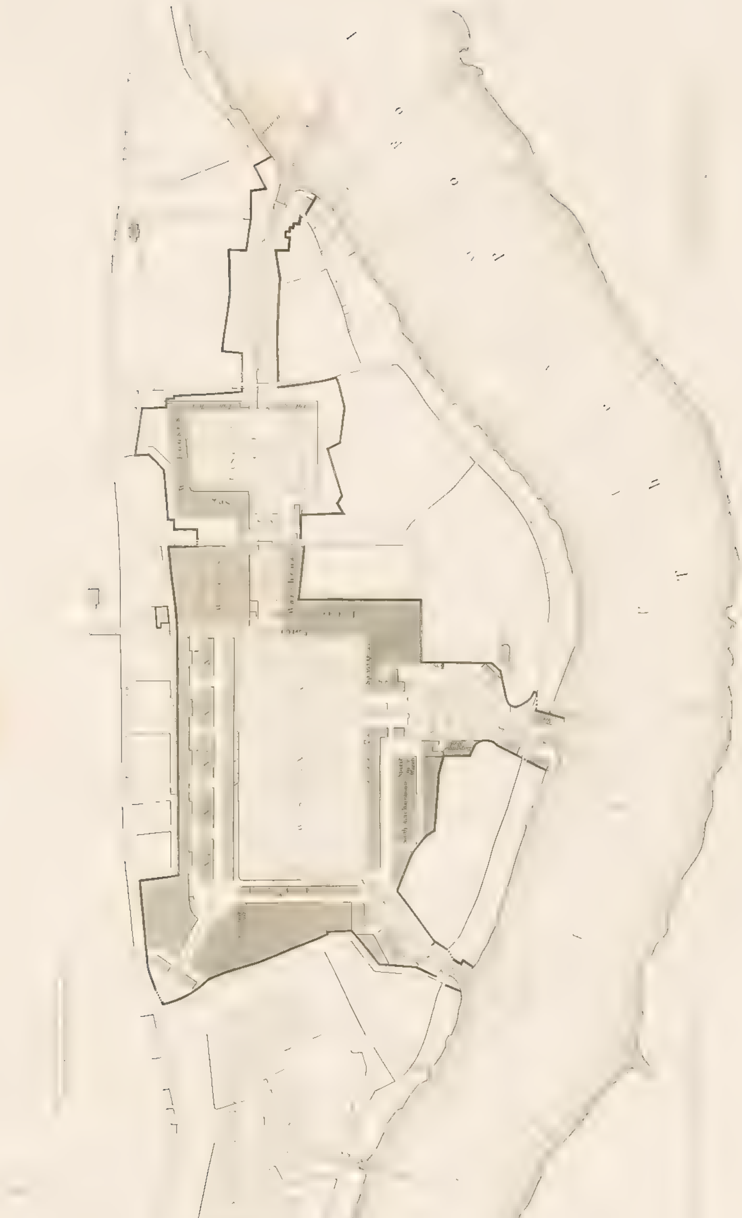


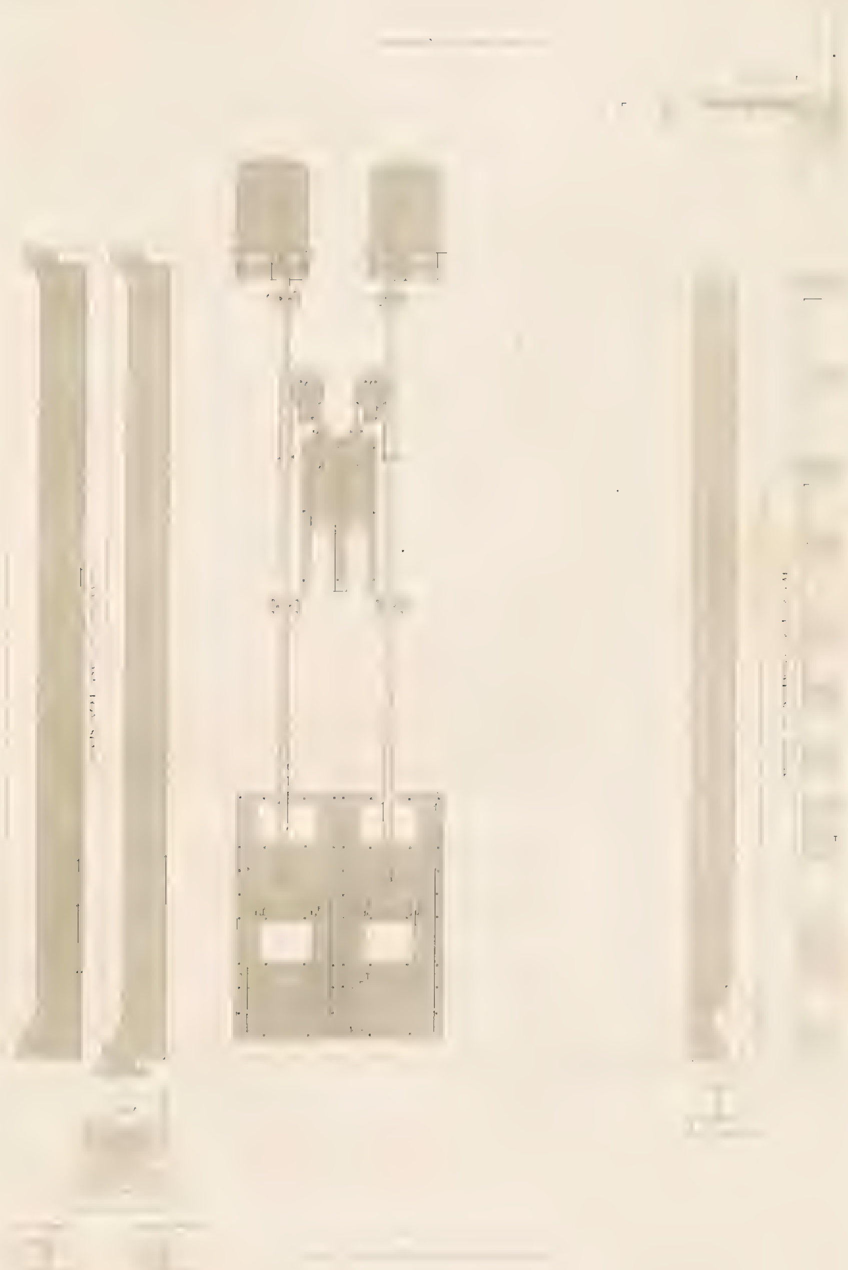


KATHARINE DOCK

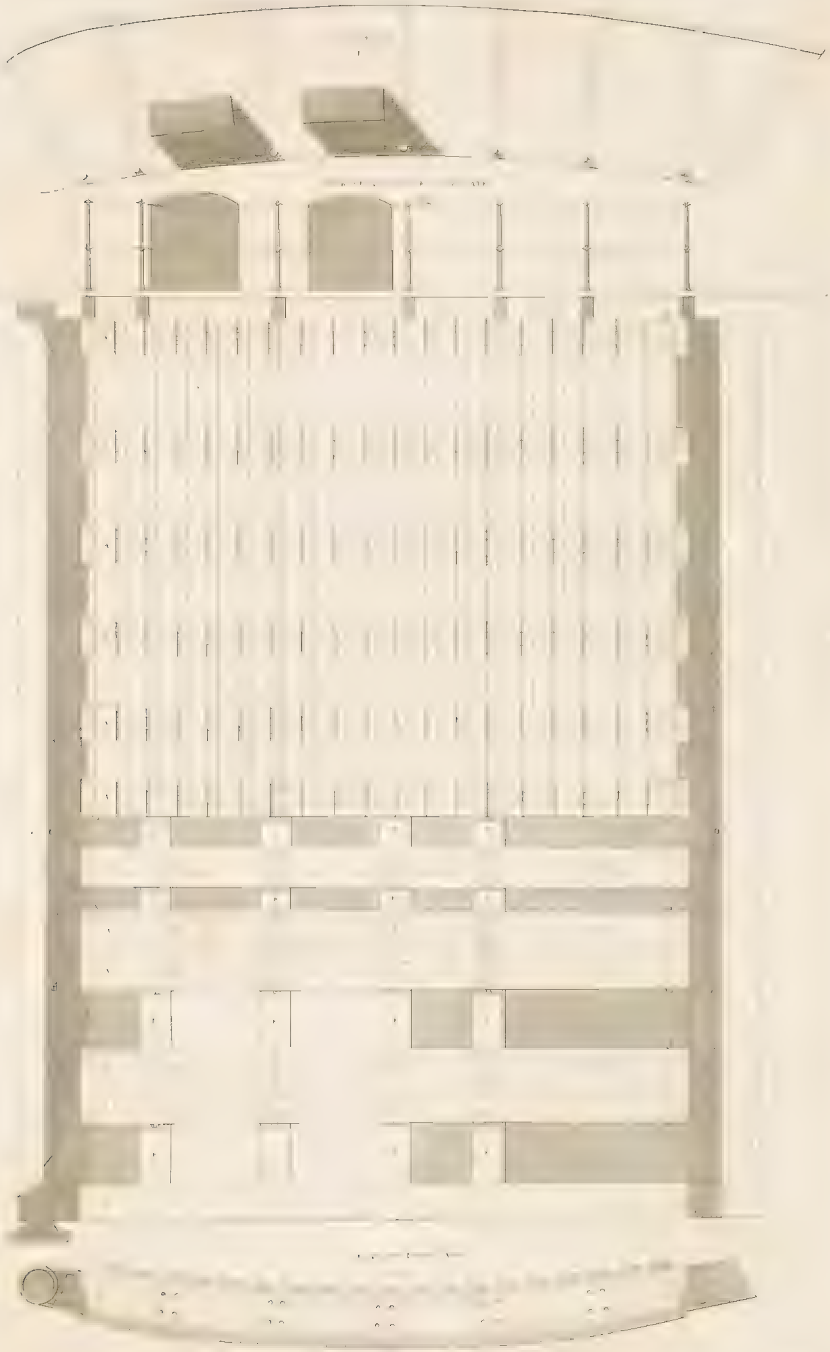


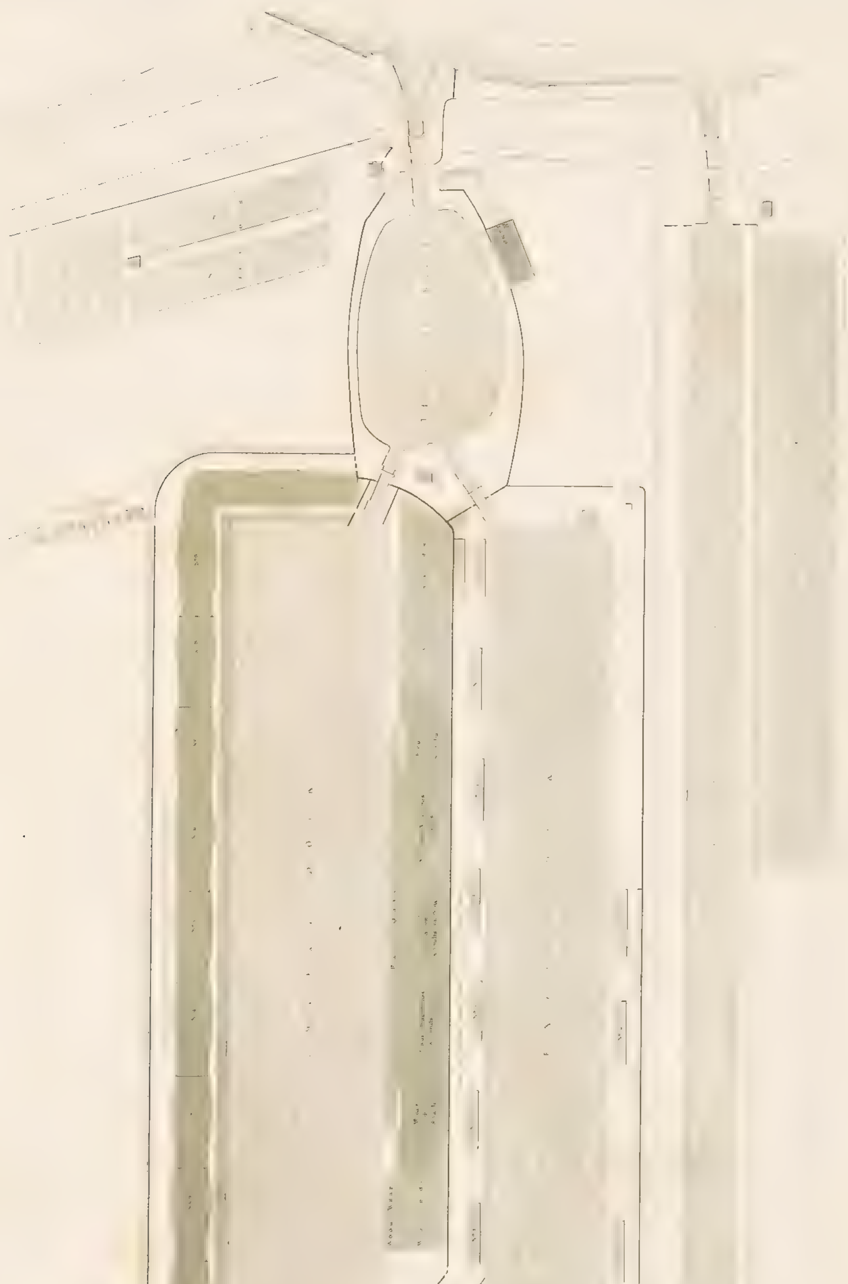


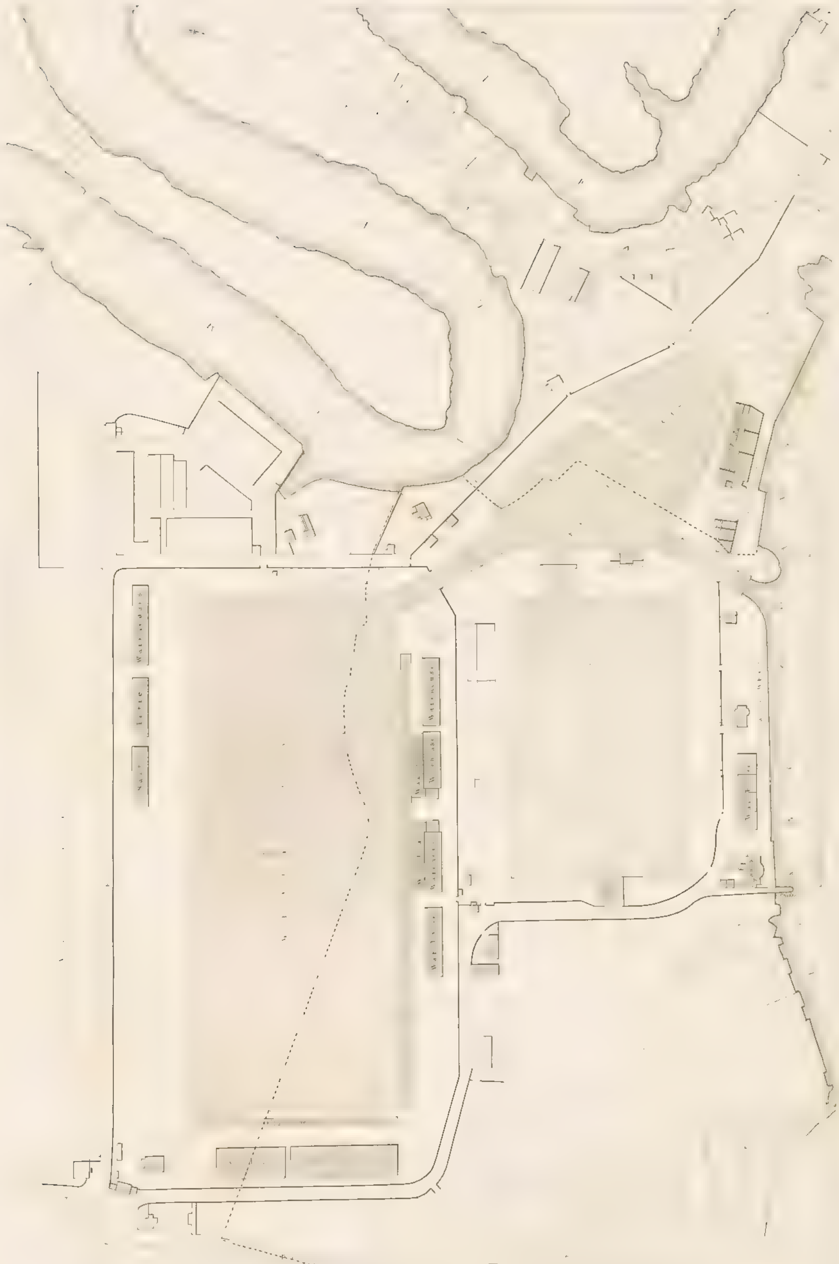


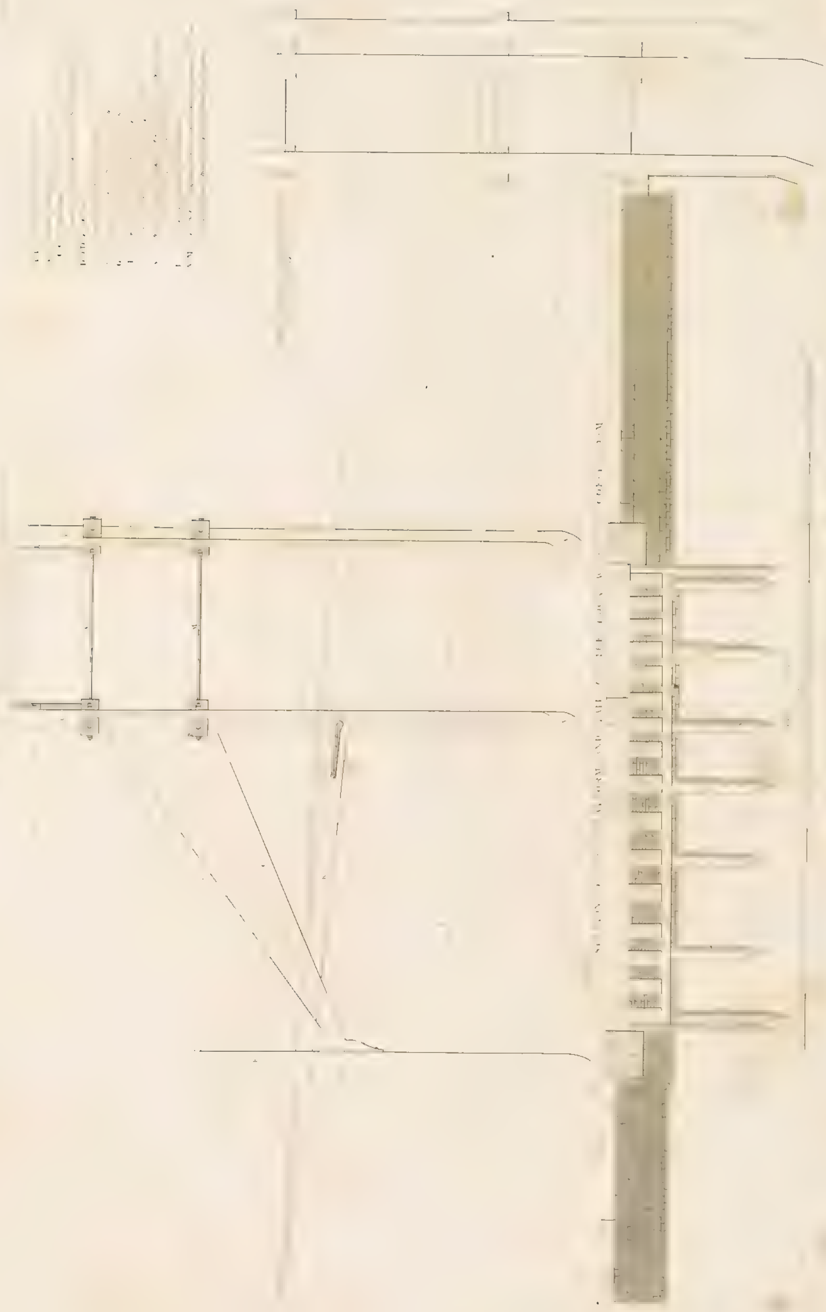


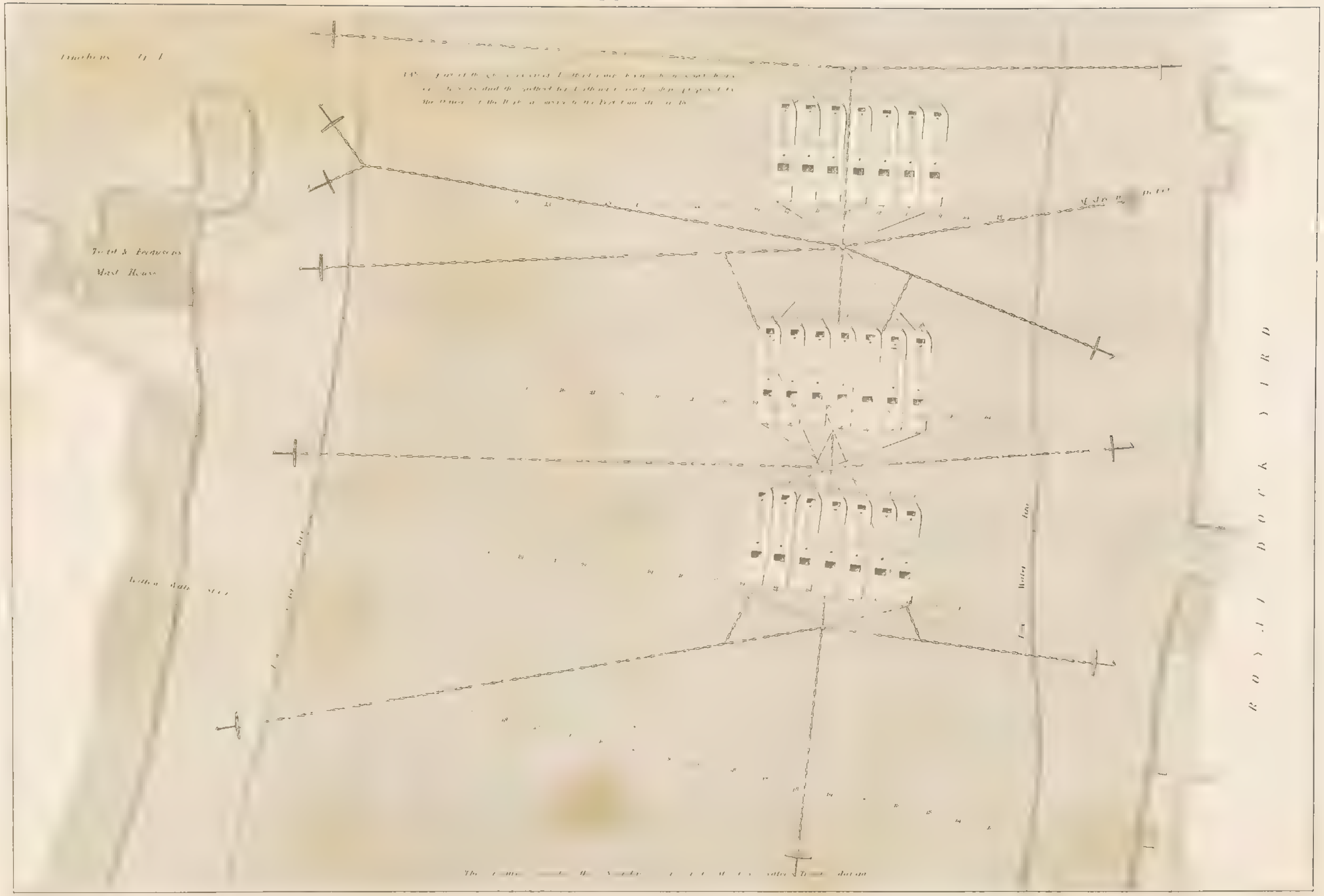
LONDON DOCKS

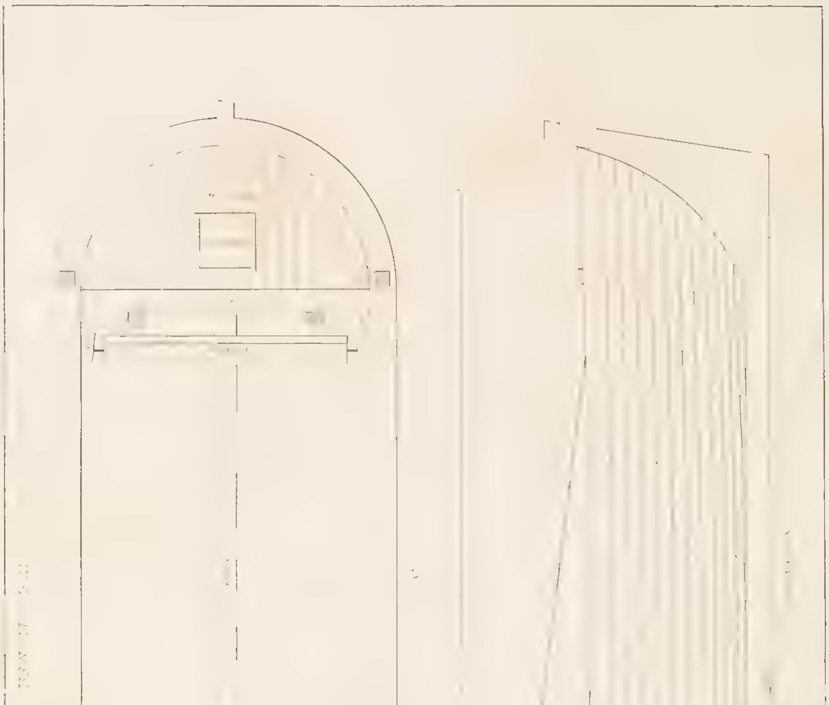


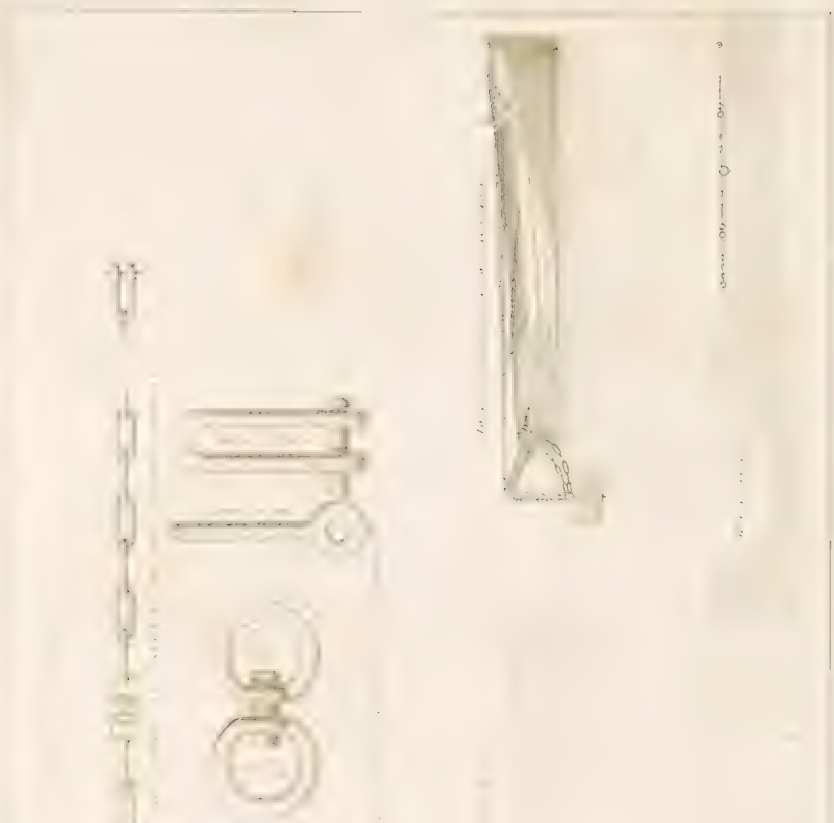






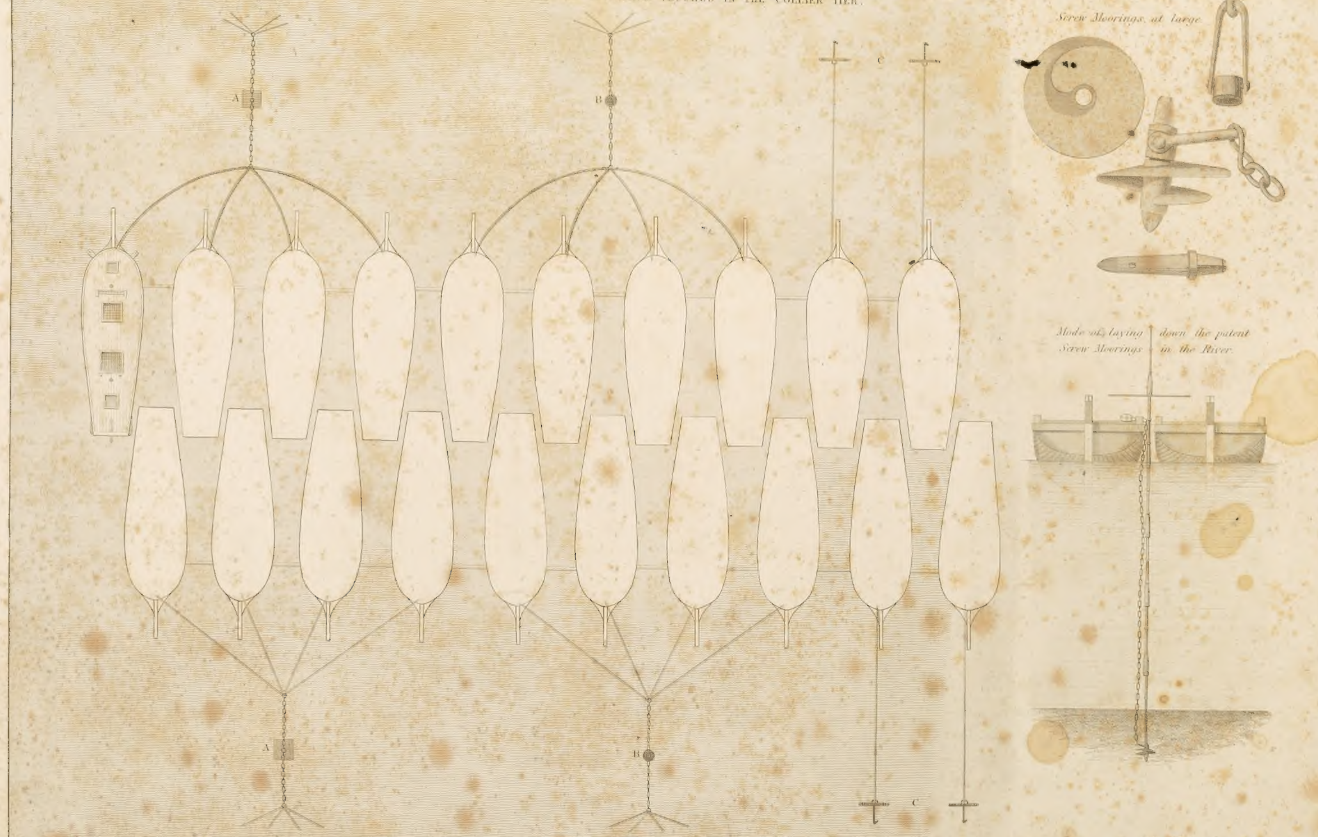

ROYAL DOCK YARD
Mast House





... of the River Thames from London bridge to Kingsbys hole with soundings at every quarter of a mile surveyed and take ...
with those taken by the Harbour masters and by George Rennie Esquire F.R.S.

THREE MODES OF MOORING VESSELS IN THE COLLIER TIER.



A.A. By mooring stones. B.B. By Mitchell's patent screws in Mill-hole tier. C.C. By their own Anchors.

James Glover, Surveyor at the Port of London, del.
John Weale, Architectural Library, 59 High Holborn.
Roffe Sculp.